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ABSTRACT

This document contains skills standards for concrete construction workers that are designed for the following purposes: to inform prospective construction workers about the type of work and the skills required so that they can make informed career decisions; to inform educators about how academic, workplace, and life skills are applied in industry; and to provide construction contractors and their local union partners with a means to ensure that their workers are trained and have the skills necessary to keep them competitive in a global economy. The skills standards were developed by representatives of the laborers and the industry using two task identification techniques (Modified DACUM--Developing a Curriculum--and an extended search of published references) to generate a list of tasks, skills, knowledge, and aptitudes for each job. Tasks were validated in the following ways: structured interviews, critical incident discussions, and surveys used with front-line supervisors, trainers, and supervisors and interviews with more than 200 construction craft laborers. The document contains 11 concrete worker skill standards and 22 workplace skills, knowledge, and aptitudes standards in the areas of aptitudes and abilities, workplace basic skills, cross-functional skills, and occupation-specific knowledge. The concrete worker skill standards consist of a scenario that describes the construction process, conventional industry standards, key tasks, and workplace skills, knowledge, and aptitudes. Each of the workplace skills, knowledge, and aptitudes standards contains the following elements: a context, a mastery performance level, the content, references to which job functions the standard applies, and referenced to the key tasks and activities in which the standard is included. (KC)

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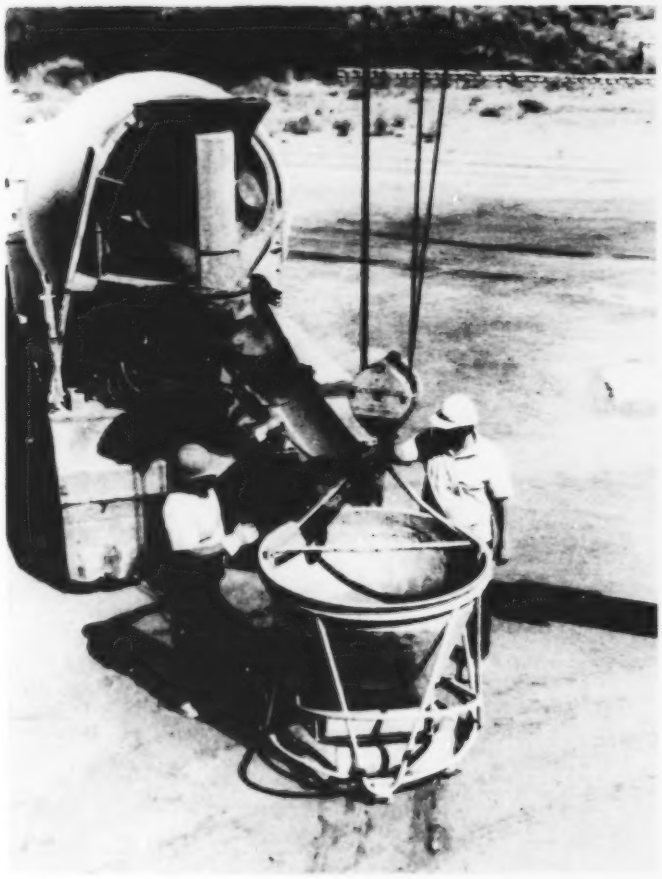
Concrete Worker Skill Standards



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Introduction

Origin and Purpose of Skill Standards

The Laborers-AGC Education and Training Fund (Laborers-AGC) Business and Education Skill Standards Project (BESP) is one of 22 pilot projects designed to develop and use work place skill standards to help the North American work force compete in an increasingly global marketplace. Funded in part by a grant from the U. S. Department of Education, the project's main goal is to generate world-class skill standards based on an analysis of the tasks a worker performs on the job, as well as the skills, knowledge, and aptitudes necessary to perform the work successfully.

Laborers-AGC elected to undertake this project to improve the skills of construction craft laborers and increase the market share of their employers in the heavy/highway construction and environmental remediation industry sectors.

"The changing work place and marketplace demand that LIUNA take the lead in setting training and skill assessment standards in order to offer our members and signatory contractors the best service in the industry. As always, we are ready to meet the challenge."

Arthur A. Coia, General President
Laborers' International
Union of North America

Laborers-AGC believes that these skill standards will:

- Promote recognition of the construction craft laborer's multiple skills.
- Enable trainers and educators to develop curricula that are relevant to the industries.
- Assist labor unions and employers in gaining market share by ensuring the skills of their workers.

For skill standards to be effective, workers, educators, trainers, labor union officials, and contractors and suppliers must use the standards.

- *Workers* must review the standards and seek training in areas in which they are not skilled.
- *Educators and trainers* must adopt the standards and pattern their curricula and assessments around them.
- *Labor union officials* must acknowledge the value of workers who possess these skills and encourage their members to obtain them.

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- *Contractors and suppliers* must demand workers who possess these skills and continually provide feedback to educators and trainers about the quality of training.

Development of Skill Standards

In an effort to make these skill standards useful for all stakeholders, Laborers-AGC invited experts from labor, management, and education to join two coalitions to guide the process. One coalition directs the development of skill standards for the heavy/highway construction industry and the other directs the work for the environmental remediation industry.

During development, staff used two task identification techniques—Modified DACUM (Develop A Curriculum) sessions and the Extended Search of published references—to generate a list of tasks, skills, knowledge, and aptitudes for each job.

"The most important part of the pilot project was the front-line worker interviews. These interviews allowed working construction craft laborers to describe in detail the skills they need and equally important, what skills they expect their coworkers to possess."

John Tippie, Project Director
Laborers-AGC Business and Education Standards

To ensure that the tasks included were valid and important to each of the jobs, three validation techniques (i.e., structured interviews, critical incident discussions, and surveys) were used with front-line workers, trainers, and supervisors. More than 200 construction craft laborers from different areas of North America were interviewed and rated the importance and frequency of tasks, skills, knowledge, and aptitudes.

The project aimed to compile a complete industry viewpoint on the tasks performed by workers in each of the job categories investigated. Validation sessions were held throughout North America to ensure geographic representation of the construction processes and tasks. Similarly, both union and nonunion workers were invited to participate in the interviews and surveys to ensure that a full array of practices were considered.

Figure 1 depicts how these skill standards fit into the construction industry.

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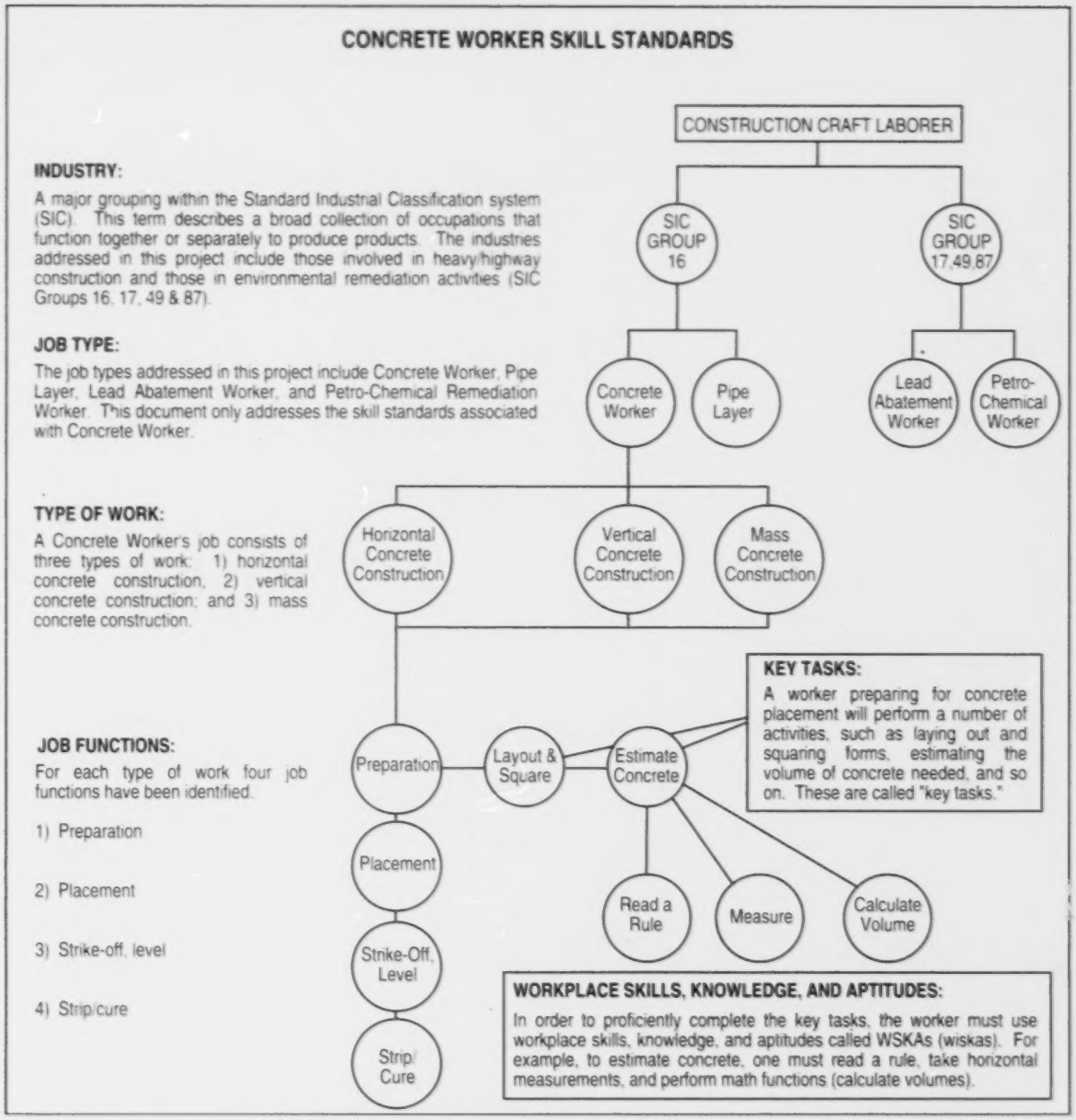
CONCRETE WORKER SKILL STANDARDS
INDUSTRY:
A major grouping within the Standard Industrial Classification system (SIC). This term describes a broad collection of occupations that function together or separately to produce products. The industries addressed in this project include those involved in heavy/highway construction and those in environmental remediation activities (SIC Groups 16, 17, 49 & 87).
JOB TYPE:
The job types addressed in this project include Concrete Worker, Pipe Layer, Lead Abatement Worker, and Petro-Chemical Remediation Worker. This document only addresses the skill standards associated with Concrete Worker.
TYPE OF WORK:
A Concrete Worker's job consists of three types of work: 1) horizontal concrete construction, 2) vertical concrete construction; and 3) mass concrete construction.
JOB FUNCTIONS:
For each type of work four job functions have been identified.
1) Preparation
2) Placement
3) Strike-off, level
4) Strip/cure
CONSTRUCTION CRAFT LABORER
SIC GROUP 16
SIC GROUP 17,49,87
Concrete Worker
Pipe Layer
Lead Abatement Worker
Petro-Chemical Worker
Horizontal Concrete Construction
Vertical Concrete Construction
Mass Concrete Construction
Preparation
Layout & Square
Estimate Concrete
Placement
Strike-Off, Level
Strip/ Cure
Read a Rule
Measure
Calculate Volume
KEY TASKS:
A worker preparing for concrete placement will perform a number of activities, such as laying out and squaring forms, estimating the volume of concrete needed, and so on. These are called "key tasks."
WORKPLACE SKILLS, KNOWLEDGE, AND APTITUDES:
In order to proficiently complete the key tasks, the worker must use workplace skills, knowledge, and aptitudes called WSKAs (wiskas). For example, to estimate concrete, one must read a rule, take horizontal measurements, and perform math functions (calculate volumes).

Figure 1
BESP Structure

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Use of Skill Standards

The purpose of this document is to identify skill standards for concrete construction in a manner that is easy to understand, useful, and meaningful to workers, educators, trainers, labor leaders, contractors, and project owners. To best achieve this goal, the coalition selected a format that uses scenarios to provide the reader with a picture of the construction process under consideration. The scenarios are designed specifically to provide a general description of the complete concrete construction process. They are not intended to describe or prescribe craft worker jurisdictions or specialty construction methods and should not be interpreted as such.

Since concrete is the most common building material in the world, these skill standards cannot describe every type of use and construction process. Instead, Laborers-AGC elected to deal with job functions and selected several categories based on the primary types of construction in North America. Each category depicts a different application of concrete as a building material. When combined, the applications provide a representative cross-section of the skills required to succeed in the industry.

The coalition envisions the standards will be used by many entities. However, we expect the primary users will be prospective and existing construction workers, the educational community, construction contractors and their associations, construction training organizations, and labor organizations.

Each of these entities will have a different application of the standards and each will seek different information. For that reason, we have designed the standards with four informational components:

1. **Scenario** – The scenario describes the construction process and conveys the contextual information needed to understand the various applications of work place skills, knowledge, and aptitudes. In addition, the scenario includes or implies conventional industry standards that can serve as performance criteria.

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2. **Conventional Industry Standards** – Conventional industry standards contain accuracy or production requirements that serve as performance criteria. This information provides valid criteria for the design and implementation of assessment routines and informs the reader of the quality required during various steps of the construction procedure.

3. **Key Tasks** – The key tasks are selected from a master task list as identified and rated by incumbent workers. Since it would be too lengthy and detailed to present the complete task list for every operation, only the tasks rated by workers as the most important and frequently performed are included.

4. **Workplace Skills, Knowledge, and Aptitudes** – Relevant Workplace Skills, Knowledge, and Aptitudes (WSKAs) are listed with the standard's other components. In addition, directly following the standards is a section containing detailed description of key WSKAs as identified and verified by workers. Each WSKA includes the context, the mastery performance level, the content for training, and scenario(s) and relevant tasks to which it applies. The information enables curriculum development and performance assessment.

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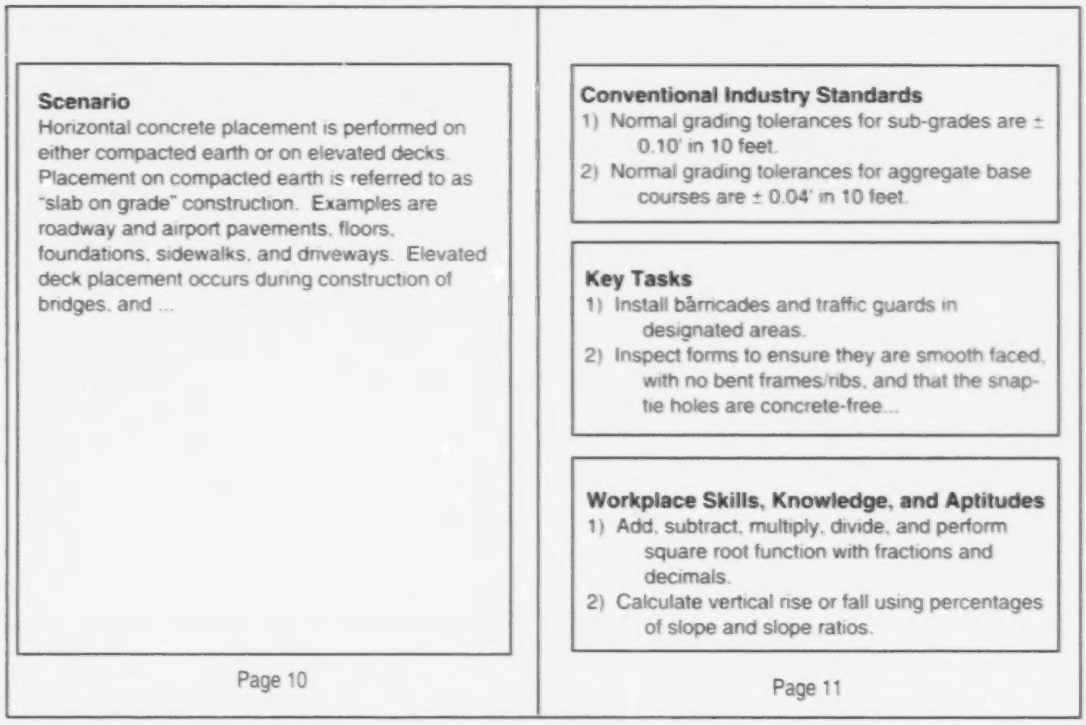
Organization of Skill Standards

As shown in Figure 2, each standard is presented on facing pages with the scenarios adjacent to the key tasks, conventional industry standards, and WSKAs. The design and format enable every potential user of these standards to find the information they require quickly and efficiently.


Scenario
Horizontal concrete placement is performed on either compacted earth or on elevated decks. Placement on compacted earth is referred to as "slab on grade" construction. Examples are roadway and airport pavements, floors, foundations, sidewalks, and driveways. Elevated deck placement occurs during construction of bridges, and ...
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Conventional Industry Standards
1) Normal grading tolerances for sub-grades are ± 0.10' in 10 feet.
2) Normal grading tolerances for aggregate base courses are ± 0.04' in 10 feet.
Key Tasks
1) Install barricades and traffic guards in designated areas.
2) Inspect forms to ensure they are smooth faced, with no bent frames/ribs, and that the snap-tie holes are concrete-free....
Workplace Skills, Knowledge, and Aptitudes
1) Add, subtract, multiply, divide, and perform square root function with fractions and decimals.
2) Calculate vertical rise or fall using percentages of slope and slope ratios.
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Figure 2
Sample Skill Standard Layout

The anticipated users, as well as the information and benefits they will derive from using the standards, are described as follows:

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"These standards accurately describe the type of skills and knowledge that make a good concrete laborer. If prospective concrete workers read the standards and demonstrate that they can perform the key tasks, they will do well in this industry."

Grover Johnson, Concrete Foreman and Training Instructor
Northwest Laborers-Employer Training Trust Fund

Workers

Workers in the construction industry should use these standards as a benchmark for the skills they must possess to be successful in the construction work place. These standards reflect what employers expect of workers; therefore, without the skills, knowledge, and aptitudes, job prospects and consistent earnings will be more difficult to attain.

A worker should read the scenarios to recognize which aspect of a job is being described. Next, the worker should read the key tasks associated with that scenario, making sure he or she knows how to perform each task. This document can be used as a checklist. When the worker encounters a skill he or she does not possess, he or she should seek outside or on-the-job training, or begin self-study of the skills he or she does not yet have. To be considered proficient in these tasks, the worker must be able to perform the tasks according to conventional industry standards and recognize that different jobs may require different skills.

Workers also can compare their current skill levels in math, communication, safety, and other topics with the information found in the WSKA portion of these skill standards. The skills, knowledge, and aptitudes are considered prerequisites for performance of the relevant tasks. Again, a worker can determine what prerequisite skills he or she needs by comparing his/her knowledge with the WSKA list.

Once the credentialing part of this project is created, workers will have a way to document what they know and use it as a selling point when seeking employment. To increase marketability, a worker should take an inventory of his or her skills using these standards, master the skills he or she doesn't yet have, and document the skills for current or future employment.

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"Our coalition designed the WSKAs to contain a context, a content, and performance levels. These skill indicators enable educators to easily adapt their curriculum to include examples and assessments."

Carl Horstrup, Department Chair, Industrial Technology Program
Lane Community College

Educators and Trainers

The scenario component is designed to convey contextual information to educators. It describes the construction process and how a worker must use the work place basic skills and knowledge that schools teach. Furthermore, information contained in the specific WSKAs enables educators to evaluate their curriculum, design instructional material, and build tests around measurable performance criteria and necessary work-based content.

Information contained in the conventional industry standards component will assist industry trainers in designing valid performance assessment tools. The key task component informs trainers of the most important tasks their trainees are expected to perform. This information enables trainers to design applicable, hands-on manipulative training exercises. When lessons and training strategies are designed around these standards, the schools and training facilities have a valid set of goals and objectives, measurable performance indicators, task lists, and necessary WSKAs to develop classroom and hands-on exercises. The resulting training process enables facility administrators to promote the credibility of their programs within the community and the industry, and with accreditation agencies.

The skill standards will help educators devise appropriate programs by providing educators, employers, and employees a common language for talking about skill needs and training goals. The result is strengthened relationships between workers, educators, and employers, as well as schools that will be capable of providing better preparation and career advice to prospective construction workers.

Employers

An unskilled worker on the job can cost a contractor in many ways, such as delaying the progress of the job, creating penalties for the contractor, causing accidents that lead to increased worker compensation costs and public safety hazards, and making errors that may result in loss of profit.

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A skilled work force is one of the most important ingredients to a contractor's success, which is why skill standards are so beneficial.

A contractor with a team of highly skilled workers can develop a strong reputation and an important element with which to market the company. Additionally, when a contractor needs additional workers, he or she can request a worker with specific identified skills and be guaranteed the worker knows the job.

"A contractor's survival and profitability is determined in large part by the efficiency and effectiveness of the work force. Ensuring that workers' skills fit the needs of the job site is a bottom-line economic necessity."

John Heffner, Executive Director
Training and Educational Services
Associated General Contractors of America

Employers also will benefit by ensuring that revenue contributed to joint labor/management training funds will be used for training occupational skills versus academic skills which will be addressed by schools that adopt the standards.

All employers involved in training can, through this document, have access to the industry's best skills data and training strategies. Contractors will be able to use the standards information to restructure work assignments so as to enable a high-performance work place.

In order for any employer (contractor or otherwise) to experience these benefits however, everyone must do their part. An employer's most vital role is to encourage the use of these skill standards by supporting their implementation in local schools and training funds, and by requesting workers that have demonstrated they possess these skills through training or job experience.

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"We can achieve success only if employers, employees, educators, and communities across America want this to succeed."

James R. Houghton,
National Skill Standards Board
Chairman and Retired Chairman
and Chief Executive Officer
Corning Corporation

Summary

Skill standards provide benefits to all stakeholders by emphasizing quality of production, safe work environments, and ensuring lifelong learning and earning for workers. They also improve the industry image which attracts workers, increases confidence in products in the broader community, and improves profit margins by ensuring quality, improving skills, and boosting efficiency of workers at all levels.

The standards are designed to be used by all stakeholders in the concrete construction industry. Stakeholders include:

- *Workers* who seek lifelong employment in the construction industry.
- *Labor leaders* who work together with their signatory contractors to staff the most intricate construction projects in history.
- *Employers* who strive to remain competitive in an increasingly global marketplace.
- *Educators and trainers* who need accurate descriptions of the work to teach the basic skills to perform it.
- *Project owners* who must choose among competing contractors.
- *Members of the general public* who purchase, use, and benefit from concrete products.

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Concrete Worker Skill Standards

The Concrete Worker Skill Standards follow.

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HORIZONTAL CONCRETE CONSTRUCTION: PREPARATION

Scenario

Horizontal concrete placement is performed either on compacted earth or on elevated decks. Placement on compacted earth is referred to as "slab-on-grade" construction. Examples include airport and roadway pavements, floors, foundations, sidewalks, and driveways. Elevated deck placement occurs during construction of bridges and multi-story buildings.

Slab-on-Grade - Slab-on-grade construction begins with clearing and removing all organic materials, such as peat, grass, tree roots, etc. Next, the earth under the proposed concrete slab (subgrade) is excavated and/or filled to the design elevation, shaped, and compacted to the specified density. The amount of material added or removed depends on the elevation of the existing soil and the amount of structural fill required by project specifications. During excavation, the subgrade is shaped to the same slope as the proposed finished surface. Once the subgrade is compact and uniform, structural fill and aggregate base material are added, graded, and compacted.

As each level of material is added and graded, the tolerance for deviation away from uniform becomes smaller. Grading tolerances are set according to industry standards or as specified for each project. Normal tolerances for the subgrade level are ± 0.10' (30 mm) deviation from design elevation in 10' (3.05 m) horizontal distance and ± 0.04' (12 mm) in 10' (3.05 m) horizontal distance for the aggregate base level.

Following subgrade and base preparation, stakes are driven and string lines are set to match the specified location and elevation of the finished slab. For thin slabs, 2" x 4" or 2" x 6" lumber is staked at the elevation and location of the string line. For thicker slabs, such as airport and highway pavements, steel forms are used. The base material must uniformly support the steel forms as concrete placement and finishing equipment often ride on the forms. Industry standards for deviation from design elevation of the forms vary with project specifications; however, most projects require the forms be ± 0.02' (6 mm) of design elevation.

After forming, expansion joint filler material is placed and secured at specified locations and elevations. Contraction (control) joint locations are marked on the forms so the joints can be constructed after placement. Reinforcement and all necessary embedded objects are installed at the specified location.

Elevated Deck - Preparation for elevated deck construction differs from slab-on-grade construction in that there is no grading work. Instead, workers check to ensure that the supporting structure will bear the weight of the placed concrete. Installation of reinforcement steel and placement of embedded objects and openings is performed in the same manner as in slab-on-grade construction. The final steps before placement are to clean completely and oil the deck forms. All debris must be removed from the deck form to ensure that when the form is removed there is no debris visible in the underside of the concrete.

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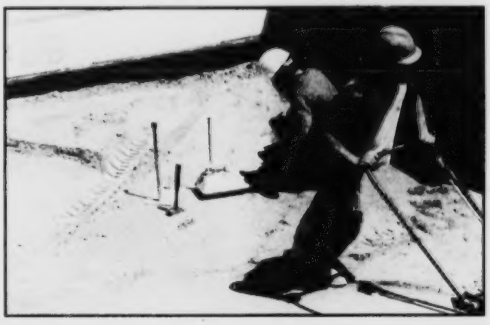
Conventional Industry Standards

1) Normal grading tolerances for sub-grades are ± 0.10' (30 mm) in 10' (3.05 m).
2) Normal grading tolerances for aggregate base courses, ± 0.04' (12 mm) in 10' (3.05 m).
3) Normal industry standards for soil and aggregate density range from 92% to 98% of maximum density.
4) Normal industry concrete form construction tolerances are ± 1/8" (3 mm).
5) Industry standards of deviation for a finished concrete slope range from 1/4" (6 mm) to 1/16" (2 mm) in 10' (3.05 m).

Key Tasks



1) Install barricades and traffic guards in designated areas.
2) Perform traffic control duties.
3) Light the work area.
4) Inspect forms to ensure they are smooth faced, with no bent frames/ribs, and that the snap-tie holes are concrete-free. They must be clean, oiled, and stacked by size with the best forms separated from others.
5) Lay out and square area and mark form locations.
6) Grade subgrade uniform with finished slab to within 0.10' (30 mm) over 10' (3.05 cm).
7) Compact subgrade to specified density.
8) Drive stakes plumb to secure forms.
9) Assemble forms tight with minimal leakage.
10) Install reinforcement (if specified) of correct type, in appropriate locations.
11) Install waterproof membrane (if specified) without leaks.
12) Mark contraction and expansion joints accurately within 1/4" (6 mm) so they remain visible after finishing.
13) Inspect bracing and supports of all forms.
14) Recheck final preparation with blueprints.

Workplace Skills, Knowledge, and Aptitudes

1) Add, subtract, multiply, divide, and perform square root function with fractions and decimals.
2) Calculate vertical rise or fall using percentages of slope and slope ratios.
3) Select and use either the Metric, Decimal, or U.S. Standard systems of measure.
4) Use clearing equipment, such as a chain saw.
5) Use proper techniques to measure accurately both horizontally and vertically.
6) Set up and use common differential leveling equipment from standard survey reference stakes to check subgrade, finished grade, and concrete form elevations.
7) Apply squaring principles from standard survey reference stakes to layout right angles and ascertain squareness.
8) Work as team member to make grade measurements and install forms.
9) Demonstrate good eye-hand coordination.
10) Use eyes to spot for level.
11) Know and apply principles of soil compaction and operation of compaction equipment.
12) Know soil density testing practices and procedures.
13) Keep work areas free of tripping hazards and foreign objects.

HORIZONTAL CONCRETE CONSTRUCTION: PLACEMENT

Scenario

Placing concrete is the process of moving concrete from the delivery truck to its final position, consolidating (vibrating), and screeding (striking off) to near its design elevation. Placement is accomplished directly from a delivery truck, or transported by manual or powered concrete buggies, conveyor belts, pumps, or by crane-hoisted concrete buckets.

Slab-on-Grade - Direct deposit from the mixer truck is used for slabs which are easily accessible and where reinforcements or embeds do not interfere with truck movement. Prior planning for traffic control is essential when using this method of placement. During placement, segregation of the aggregate from the cement paste must be avoided. Causes of concrete segregation are:

1) free fall distances over 3' (1 m)
2) vibration during delivery
3) over vibration during consolidation
4) using vibrating equipment to move concrete laterally

Workers begin consolidation as soon as concrete is placed. The consolidation process frees entrapped air, distributes the cement paste around the aggregate, and settles the concrete into the forms. For thin slabs of up to 6" (150 mm), surface vibrators (vibrating screeds) often are used for consolidation. For thicker slabs, internal vibrators are used and sometimes followed by vibrating screeds. Most highway and airport paving operations use gang-mounted vibrators on the paving machine for consolidation. Screeding (strike-off) follows consolidation. During screeding, the surface of the concrete is leveled close to the design elevation. The screeding process fills in low spots and levels high spots. Tools for screeding include wood and magnesium straightedges, mechanical vibrating screeds, roller screeds, and paving machines. When screeding by hand, a wood or magnesium straight edge is set on the forms or screed bars on two sides and pulled to strike the concrete to the same level as the forms or bars.

Elevated Deck - The placement process for elevated decks is the same as slab-on-grade except the delivery method varies. For construction that requires delivery by buggies, smooth runways and traffic control patterns are planned and constructed in advance. This will prevent segregation of the concrete during transport and prevent damage to reinforcing steel and imbeds. Conveyors are used when it is necessary to move concrete long distances and when placement must be continuous. Conveyor belts are set up to ensure the discharge will reach all areas of the slab. In addition, good cleanup is essential to ensure trouble-free operation.

Pumping is used when space is limited or the area is not accessible to other equipment. The most frequently used concrete pumps are truck mounted with placing booms that extend and articulate to place concrete where needed. Pumps should be located as close to the placement area as possible to permit easy delivery truck access. Pump lines are assembled using a minimum of bends and turns, and must be inspected and cleaned before and after placement. Communication with the pump operator through hand signals or two-way radios is crucial to a smooth placement operation. Crane-hoisted concrete buckets are used in smaller areas that do not require continuous placement. Control of the bucket's discharge gate is essential to maintain an even, steady flow of concrete. In addition, communication with the crane operator must be maintained to ensure accurate delivery.

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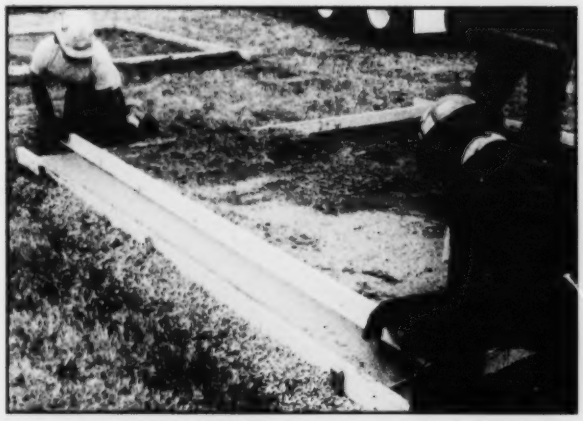
Conventional Industry Standards

1) Concrete is placed with a drop of less than 3' (1 m) to prevent aggregate separation.
2) Concrete is placed so load is distributed to the entire area.
3) Concrete is struck off so a small ridge of material (1" or 25 mm) is pushed in front of the screed. The excess material pushed by the screed should not be higher than 2" (50 mm).



Key Tasks

1) Check readings, such as slump, as well as environmental conditions.
2) Dampen subgrade or subbase uniformly.
3) Introduce admixtures, as directed or as appropriate to meet environmental conditions.
4) Assemble tools for placement and finishing at work site.
5) Double check marked locations for joints.
6) Place concrete as close as possible to its final location, using techniques and equipment specific to the site.
7) Begin placement in corner and deposit new concrete against previously placed concrete.
8) Consolidate concrete with appropriate vibrator.
9) Pre-level concrete with shovel or comealong before screeding.
10) Screed/strike-off concrete with straight edge or power screed to fill low spots and remove excess material.

Workplace Skills, Knowledge, and Aptitudes

1) Lift and move heavy objects.
2) Demonstrate manual dexterity and eye-hand coordination.
3) Work in areas of constricted movement.
4) Estimate material needs in a given area.
5) Read gauges and instruments.
6) Select and use appropriate personal protective equipment.
7) Work as a member of a team.
8) Practice sound electrical safety procedures.
9) Identify appropriate tools for horizontal placement and finishing.

HORIZONTAL CONCRETE CONSTRUCTION: STRIKE OFF, LEVEL, AND FINISH

Scenario

Concrete is finished in order to leave a smooth, dense, and wear-resistant surface. The finishing process covers the concrete aggregate with cement paste and levels the surface to the specified flatness. Degrees of flatness are project specific for different applications. For example, a residential driveway usually will not have specific tolerances, but a factory floor where robotic equipment will operate may require a very flat floor.

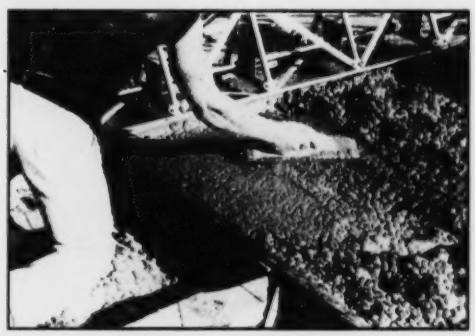
Different tools are used to level concrete based on project flatness specifications. For slabs, such as driveways and small parking lots, a bullfloat is used immediately after screeding and before bleed water appears. The bullfloat fills voids and levels ridges left by the screed and prepares the slab for further finishing. When finishing with a bullfloat, conventional accuracy requirements are 1/2" (13 mm) deviation in 10' (3.05 m) horizontal.

Highway straightedges are used for slabs that have greater flatness requirements. The straightedge is usually 6' (2 m) to 12' (4 m) in length and is used immediately after screeding to perform the same leveling operation as the bullfloat. Conventional accuracy for a straightedge is 5/16" (8 mm) deviation in 10' (3.05 m) horizontal.

Before further finishing operations begin, workers ensure that bleed water is gone, and that the concrete sustains foot pressure with only slight indentation. Finishing before the bleed water has evaporated will cover water pockets and cause surface scaling after the concrete has hardened.

Edging and jointing are the next steps in the finishing process. Edging provides a neat, chip-resistant edge. The jointing process places contraction joints (for crack control) in sidewalks and smaller slabs. Larger slabs and pavements usually require sawcut joints.

Floating of the slab follows edging and jointing. Floating is performed either by hand or by machine. This process consolidates the mortar and produces a level surface. For flat and very flat slabs or pavements, a straightedge can be used after floating. Accuracy requirements for flat and very flat floors are 3/16" (5 mm) and 1/8" (3 mm) deviation in 10' (3.05 m), respectively.



For sidewalks, driveways, parking lots, and pavements that require textured surfaces for traction, brooming or texturing can be done after floating.

Troweling follows floating for slabs that require a smooth, dense surface. Troweling can be done by hand or with a finishing machine.

Slabs that require saw cutting of contraction joints must be monitored so sawing can begin as soon as the concrete has set enough that the blade will not ravel or tear the surface.

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Conventional Industry Standards

1) Degree of flatness is job specific. However, the range varies from a driveway with a standard of no standing water, to a super smooth machine floor of ± .02" (6 mm).
2) Straightedge accuracy is 5/16" (8 mm) deviation in 10' (3.05 m) horizontally.
3) Leveling with a bullfloat requires an accuracy of 1/2" (13 mm) in 10' (3.05 m) horizontally.
4) Floating operations require 3/16" (5 mm) for flat floors, and 1/8" (3 mm) for very flat floors in 10' (3.05 m) horizontally.

Key Tasks

1) Bullfloat the surface or use highway straightedges to smooth surface and fill small voids.
2) Use darby or hand float near edge of forms to smooth surface and fill small voids.
3) Wait for bleed water to evaporate.
4) Edge surface at form using appropriate tools.
5) Inspect surface for firmness before floating, troweling, or jointing.
6) Float concrete surface.
7) Cut in joints at marked locations with appropriate tools.
8) Trowel surface or install other desired surface.

Workplace Skills, Knowledge, and Aptitudes

1) Demonstrate manual dexterity and eye-hand coordination.
2) Work in areas of constricted movement.
3) Choose and use appropriate personal protective equipment.
4) Attend to required time periods.
5) Comprehend and follow sequential steps.
6) Know how to achieve different types of finishes.
7) Know how to avoid typical problems preventable during finishing.

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HORIZONTAL CONCRETE CONSTRUCTION: CURING AND FORM REMOVAL

Scenario

Curing is the process of controlling moisture and temperature to enable concrete to reach its specified strength. To avoid unwanted evaporation of the mix water, curing is started as soon as possible after finishing. Two common methods of curing are water curing and moisture retention curing.

Water curing can be in the form of ponding, sprinkling, and/or wet coverings. When ponding is used, the water level must be maintained to avoid dry spots. Sprinkling is accomplished using sprinklers or soaker hoses that provide a fine mist to keep the concrete continuously wet. Burlap is the most common type of wet covering and is placed on the surface as soon as surface damage will not occur.

Curing using moisture retention is accomplished using polyethylene sheeting, waterproof paper, or spray-applied curing compounds. Polyethylene sheeting and waterproof paper are used on uneven surfaces. Care must be taken to seal the edges and keep the moisture barrier in contact with the surface for the specified curing time. Plastic membranes may cause discoloring of the surface and are not used on architectural slabs.

Spray-applied curing compounds are used on most slabs (e.g., pavements, sidewalks, driveways) exposed to the weather. Curing compounds are applied when the concrete surface is still damp. They are applied uniformly to prevent areas of evaporation. Curing compounds can be colored to accommodate architectural slabs and must be applied at the specified mixture and rate.

Fresh concrete will freeze below 32° F (0° C). If concrete is allowed to freeze before its strength reaches 500 psi, it may be permanently damaged and most projects will require its removal and replacement. Concrete placed in cool temperatures (below 50° F or 10° C) will require a longer setting time than concrete placed at warm temperatures. In addition, concrete that is required to gain strength in only a few days must be maintained above 60° F (16° C).

Form removal for most slabs may begin eight hours after placement begins. Forms should be left in place long enough to protect the slab edges from damage. As forms are removed, care is taken to prevent damage to the forms and the fresh concrete from stripping tools. As forms are removed, they are immediately cleaned, oiled, and moved to the point of reuse or storage.

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Conventional Industry Standards

1) Specified strength is realized at the projected time, based on project specifications and the American Society Test Materials (ASTM) testing procedure.
2) Concrete is maintained at uniform moisture and temperature levels for the specified time period.
3) No surface edge damage or discoloration is caused by the stripping or curing process.
4) Removed forms are cleaned immediately and well enough to use again without additional cleaning.

Key Tasks

1) Review suggested curing procedures and assemble necessary tools, materials, and equipment.
2) Mix curing protection materials according to manufacturers' instructions.
3) Initiate and maintain prescribed curing methods.
4) Match protection method to environmental conditions.
5) Apply and maintain protection.
6) Perform form removal operation safely and carefully.
7) Remove, clean, stack, and oil forms.

Workplace Skills, Knowledge, and Aptitudes

1) Demonstrate manual dexterity and eye-hand coordination.
2) Find areas of various shapes.
3) Use ratio measures.
4) Read rulers and measure length accurately with either U.S. Standard or Metric measure.
5) Read/interpret material safety data sheets (MSDSs).
6) Read/interpret blueprints for material locations, specifications, and other pertinent information.
7) Select and use appropriate personal protective equipment.
8) Wear proper dust masks and/or respirators.
9) Identify and know procedures to adapt to/control environmental problems.
10) Read and follow directions.
11) Follow appropriate time periods.

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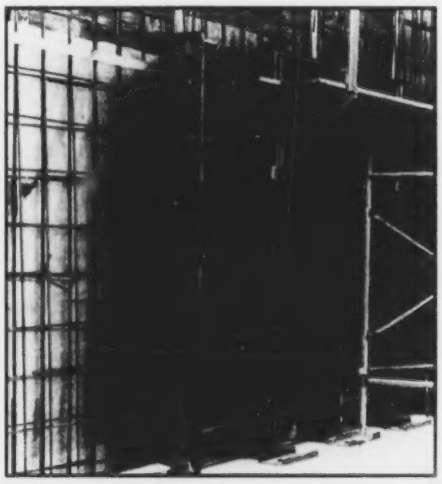
VERTICAL CONCRETE CONSTRUCTION: PREPARATION

Scenario

Vertical concrete work consists of the forming and casting of walls, columns, piers, pier caps, beams, girders, and other similar objects and structures.



Forms may be job-built or prefabricated and moved to the job site. They may be constructed of wood, steel, or fiberglass, but all must be constructed so they withstand the loads and pressures imposed by concrete materials, equipment, and workers.

Concrete workers must have knowledge of the different forming materials and accessories. They must be able to estimate the forming material needs and location. Storage of excess forming materials too close to the work area creates congestion and reduces efficiency. Not storing enough forming materials close to the work results in lost production time because of material and accessory restocking.

Forms must be built to project specifications and properly located to obtain the correct shape, size, and location of the structure. They are aligned on preset chalk line marks, by measurements from reference points, or through the use of survey equipment, such as a transit or laser. Except in special situations, forms must be constructed and secured plumb.

Prior to assembly, forms must be cleaned, inspected for damage, and oiled. Depending on the size of the forming components, they may be set in place by hand or crane. As forming progresses, reinforcements, openings, and embeds are placed and secured. Bulk heads (used for construction joints) and isolation joints are installed.

Openings may be built into tall, irregular form shapes to allow access to concrete placement and consolidation equipment.

Prior to placement, a final inspection is performed to ensure that all ties, braces, reinforcements, embeds, and so forth are placed properly and secured. Final alignment also is checked and adjusted, if necessary.

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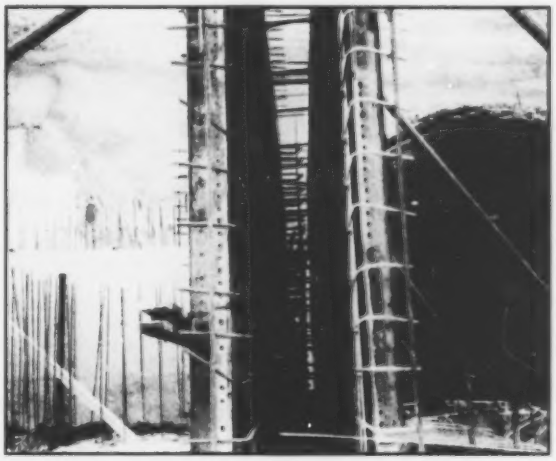
Conventional Industry Standards

1) Forms and embeds, must be located within ±1/4" (6 mm) of specified location, unless more stringent guidelines are specified.
2) Reinforcement bars must be located within 3/8" (10 mm) of design location in placements less than 8" (200 mm) thick. For placements thicker than 8" (20.3 cm), the reinforcement must be located within 1/2" (13 mm) of design location.
3) Forms must be plumb within 1/8" (3 mm) over a 5' (1.5 m) rise.

Key Tasks

1) Inspect and adjust scaffolding, working surfaces, and trench protection equipment.
2) Read blueprints and mark or confirm location for forms and other components.
3) Assemble tools and forming materials by moving and storing using whatever means appropriate.
4) Set up and use levels, lasers, and transits to mark locations and check installation.
5) Check rigging equipment and rig loads.
6) Designate signaler and review signals for moving materials.
7) Clean, inspect, and oil forms as appropriate.
8) Build/assemble/install forms and bracings of all types.
9) Place reinforcement and other embeds, and secure them.
10) Build openings and install joints.
11) Perform final inspection.



Workplace Skills, Knowledge, and Aptitudes

1) Lift and move heavy objects.
2) Demonstrate manual dexterity and eye-hand coordination.
3) Work in areas of constricted movement.
4) Estimate material needs.
5) Read rulers and measure length accurately in either U.S. Standard or Metric measure.
6) Read/interpret blueprints for material locations, specifications, and other pertinent information.
7) Choose and use appropriate personal protective equipment.
8) Inspect scaffolding before working on the platform.
9) Work as part of a team.
10) Practice sound electrical safety procedures.
11) Use proper signaling techniques.
12) Set up and use fall protection equipment.
13) Set up and use lasers, levels, and transits.
14) Know forming materials and techniques, including at least metal, wood, and fiberglass.
15) Know rigging techniques for all types of materials.
16) Use hand tools safely and effectively.

VERTICAL CONCRETE CONSTRUCTION: PLACEMENT

Scenario

Placement in vertical form work is accomplished using crane-hoisted concrete buckets or concrete pumps. Cranes deliver buckets of concrete accurately to tall, narrow forms and columns, but are seldom used where a large volume of concrete is required. A concrete pump is a better delivery device for large volume placements.

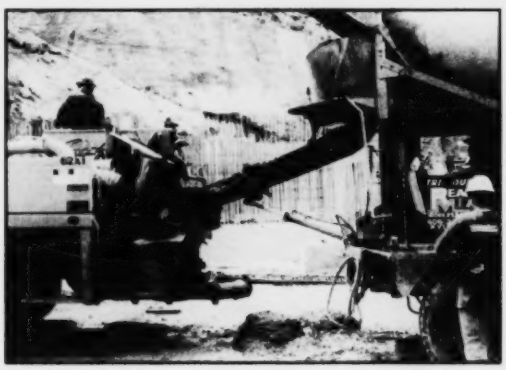
Concrete pumps, with articulating booms as long as 50 meters or more, can deliver large amounts of concrete to extreme heights or to otherwise inaccessible areas, such as bridge piers. Prior to placement, pump lines are inspected, assembled, and anchored. A concrete worker must know the different types and sizes of concrete pump lines, gaskets, and assembly clamps and assemble only compatible systems and components.

Before delivery begins, concrete pumps and pump lines are lubricated with a cement mortar called "slurry." The slurry reduces friction for the thicker concrete mix and helps prevent blockage during the initial placement stage.

During placement, the free-fall distance of concrete must be limited to prevent segregation of the mix. The concrete must be added evenly in "lifts" (or layers) to prevent uneven stress on the forms and to allow for complete consolidation.

The consolidation process is necessary to free trapped air, bond the mix to reinforcement, and fill voids. Immersion vibrators are used most commonly for consolidation, ranging from 1/2" (13 mm) to 6" (150 mm) in diameter. The size and type of vibrator used is determined by the type of form, type and location of reinforcing steel, and the type of concrete mixture. Consolidation begins as soon as the concrete is placed and each lift is bonded to the previous one by vibrating the preceding lift.

The vibrator operator avoids hitting the sides of the forms and does not over vibrate the concrete. Striking the sides of the forms with the vibrator may weaken the forms to the point of failure. Over vibration creates mix segregation and places undue stress on the forms. An industry rule of thumb is to stop vibrating when air bubbles cease forming on the surface.



As placement and consolidation continue, the forms are carefully inspected for signs of failure or movement. When forms are full, the exposed surface is struck off and finished as specified.

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Conventional Industry Standards

1) Lifts must be uniform within ± 3" (76 mm) over 20' (6.1 m) horizontal throughout the "course."
2) Concrete must be placed evenly to avoid excessive pressure in one form area.
3) Concrete must be vibrated evenly until air bubbles cease appearing on the surface.
4) Vibration must stop before the mortar and aggregate separate.
5) Concrete must be consolidated approximately 18" (.46 m) into the previous lift to ensure bonding and avoid cold joints.
6) Avoid more than one, 1" (25 mm) honeycomb within 48 sq ft (14.63 m^2).

Key Tasks

1) Inspect scaffolding before working on the platform.
2) Add/apply and integrate any specified admixtures to the concrete if necessary.
3) Select and use the correct vibrator and vibrator head.
4) Assemble placement system using compatible components.
5) Inspect, install, clean, secure, test, and lubricate hoses and other concrete conveyance devices as appropriate.
6) Fill forms in uniform heights that are within pressure limits of form. This must be done without "dropping" concrete.
7) Use vibrator to consolidate and avoid cold joint.
8) Inspect rigging equipment and rig loads as appropriate.
9) Install embeds as specified.
10) Strike off material with clean, true straightedge.
11) Finish material, as specified, including "rubbing up" small bubbles.

Workplace Skills, Knowledge, and Aptitudes

1) Work in areas of constricted movement.
2) Choose and use appropriate personal protective equipment.
3) Inspect scaffolding before working on the platform.
4) Practice sound electrical safety procedures.
5) Estimate material needs.
6) Use proper signaling techniques.
7) Set up and use fall protection equipment.
8) Know rigging techniques for all types of loads.
9) Know limits of forming materials.
10) Read and follow manufacturers' specifications/instructions.
11) Interpret the sound and feel of the vibrator.
12) Demonstrate manual dexterity and eye-hand coordination.
13) Read gauges and instruments.

VERTICAL CONCRETE CONSTRUCTION: CURING AND FORM REMOVAL

Scenario

The curing requirements and form removal procedures are planned when form work is designed and constructed. As with all concrete construction, steps to properly cure the concrete are taken immediately after placement is complete.

When placing concrete in cold weather, the form work may be left in place and cold weather protection devices (e.g., blankets and/or tenting and heating) used to protect the concrete from freezing. If early strength gain is important, the cold weather protection devices are left in place longer to ensure that the cold does not inhibit strength gain.

In hot weather placements, the forms are removed as soon as possible and wet curing methods are employed to prevent strength loss due to a lack of moisture for hydration. Wet burlap and moisture retention methods are commonly used.

As with slabs, color variations may occur when using moisture-retention curing methods. Knowledge of the effects of the moisture-retention fabrics and/or curing compounds is essential when used on architectural and exposed concrete surfaces.

When form removal begins, considerable care is required to prevent damage to the fresh concrete and the form panels from the stripping tools. When removing large forms, safety planning is necessary to prevent accidental release before cranes or other lifting equipment are ready to bear the load.

Form removal specifications for architectural concrete prohibit prying against any concrete surface. Careful handling, cleaning, and storing of architectural form work is necessary for efficient reuse of the forms.

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Conventional Industry Standards

1) Specified strength is achieved at the projected time, based on project requirements and ASTM testing procedures.
2) Moisture is maintained at the optimum level to permit hydration of the concrete and maximum strength gain.
3) Form removal avoids damage to the forms and the new concrete.
4) Removed forms are cleaned immediately, well enough to use again without additional cleaning.

Key Tasks

1) Inspect scaffolding before ascending or working on surfaces.
2) Review prescribed curing and form removal plans.
3) Match weather protection method and form removal to environmental conditions.
4) Apply and maintain heat and moisture protection.
5) Remove forms in a manner that avoids chipped surface and damaged forms.
6) Repair any surface areas that sustain damage.
7) Mix and apply curing materials according to manufacturers' instructions.
8) Inspect rigging equipment.
9) Assign signaler and clear signals before moving materials.
10) Rig and move loads.
11) Clean, oil, and stack forms.

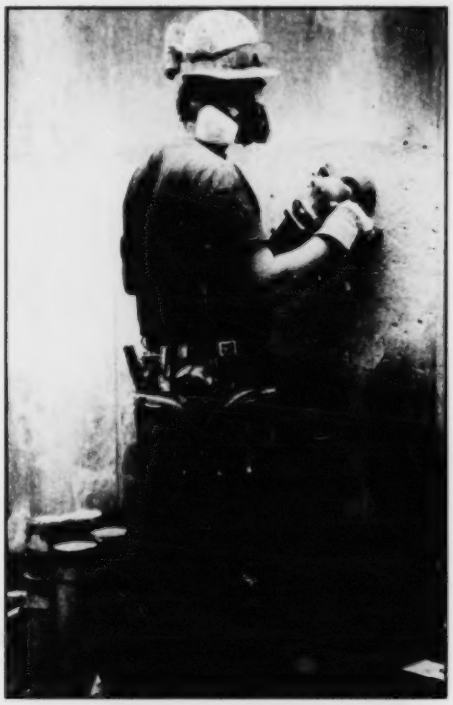
Workplace Skills, Knowledge, and Aptitudes

1) Work in confined spaces.
2) Demonstrate manual dexterity and eye-hand coordination.
3) Read/interpret MSDSs.
4) Read/interpret blueprints for material locations, specifications, and other pertinent information.
5) Choose and use appropriate personal protective equipment.
6) Identify and know procedures to adapt/control environmental problems.
7) Follow appropriate time periods.
8) Read/follow manufacturers' instructions.
9) Use ratio measures.

VERTICAL CONCRETE CONSTRUCTION: SPECIALTY FINISHES AND PATCHING

Scenario

The amount of finishing required on vertical concrete surfaces varies depending on the type of project and location of the concrete surface.



Some surfaces are left as they are after form removal, while others require additional work, such as chipping or grinding off projections, patching snap-tie holes and marks, and filling/smoothing aggregate pockets or honeycombs. Often the finishing process requires workers to create a decorative surface by exposing the aggregate or altering the surface texture.

For exposed aggregate finishes, chemical retarders, high pressure water jets, sandblasting, bushhammering, and grinders are used. The chemical retarders delay the setting of the surface mortar, allowing workers to brush or spray the top layer of mortar away and expose the aggregate. Proper timing is crucial in exposed aggregate finishes. If brushed too soon, more than the surface mortar may be removed. If brushed too late, the surface mortar will set too hard to be removed easily or efficiently.

Sandblasting, bushhammering, and grinding are used to change the surface texture in varying degrees for different architectural effects.

In order to provide a smooth finish or repair form work defects, the hardened concrete may require grinding or filling. Grinding will remove projections left from the form work and is done either by hand or with a power grinder. To fill voids, a concrete worker uses a mortar mix to fill the holes, then grinds or scrapes to smooth the mortar. Careful attention is required during the mortar mixing process to ensure that the fill material matches the exposed concrete color and texture as close as possible.

The final step for finishing is caulking, sealing, or coating. Some projects specify the application of a sealer or coating to protect the concrete or facilitate cleaning.

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Conventional Industry Standards

1) Final finish must meet specifications exactly in terms of color, surface texture, and defects.
2) Surface retardants must be applied as indicated in project or manufacturers' specifications.

Key Tasks

1) Review blueprints and specifications for exact information.
2) Assemble necessary tools and equipment.
3) Inspect scaffolding before ascending or working on surface.
4) Prepare surface for finishing, as appropriate.
5) Finish as prescribed, from exposed aggregate to smooth finish.
6) Apply bonding materials as appropriate.
7) Mix and apply finishing or patch materials as appropriate.
8) Match patch and/or finishing materials to surface.

Workplace Skills, Knowledge, and Aptitudes

1) Read/interpret blueprints for materials' locations, specifications, and other pertinent information.
2) Read/interpret MSDSs for material properties.
3) Know how to achieve various types of finishes.
4) Read/follow instructions for mixing and applying material.
5) Know characteristics of different patching materials.
6) Choose and use appropriate personal protective equipment.
7) Wear appropriate dust mask or respirator.
8) Use ratio measures.
9) Work in areas of constricted movement.
10) Practice sound electrical safety procedures.

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MASS CONCRETE CONSTRUCTION: PREPARATION

Scenario

Mass concrete placement takes place during construction of dams, power plants, silos, deep foundations, and bridge abutments. To support a large concrete structure, the earth is excavated, replaced with structural fill material, graded, and compacted to near maximum density before placing concrete. In deep excavations, in areas with high water tables, or in creation of river islands, ground water is pumped continuously out of the excavation.

Excavators, loaders, bulldozers, dump trucks, and graders, excavate the site and bring in the structural fill material. Fill material is added in 6"-12" (.15-.25 m) levels called "lifts," and compacted to density requirements. When compaction must be performed with hand operated equipment, smaller lifts are used (6" or 150 mm) and workers overlap each pass of the compaction equipment by 1"-2" (25-50 mm). Structural fill material compacts best when level and watered down just short of saturation.

Mass concrete forms hold wet concrete in place, and are either job-built, prefabricated, or manufactured. Job-built forms only may be used once or twice, stripped, and discarded. Commercially manufactured reusable forms often are used since forms can account for up to 50% of the project cost. Mass placements exert tremendous pressure on the formwork. Formwork failure represents great danger for workers close to the forms. The great pressures require uniform assembly of form ties, supports, and bracing as specified in the project plan. Another danger is the hoisting and rigging of form assemblies. On most mass concrete jobs, 2' x 8' panels are joined together (called "gang forms") on the ground in a pre-assembly area and hoisted into place with a crane or other lifting equipment.

Concrete resists crushing loads very well but can be pulled apart easily, so rebar (reinforcing bar) is strategically placed within the concrete to increase tensile strength. Rebar usually is prefabricated and delivered to the project in bundles. Each bundle is tagged with a code from the project blueprints that describes its size, shape, and design location. Rebar is sized in 1/8" (3 mm) increments, ranging from 3/8" (10 mm) to 2 1/4" (60 mm) diameter, and numbered from No. 3-11, 14, and 18. Mass concrete work normally requires No. 8 or larger, and in nuclear power facilities, the largest size, No. 18 rebar is commonly used.

Rebar is placed with a "clear space" away from the edge of the forms and the ground. The required clear space ranges from 3/4" (20 mm) to 3" (75 mm) to prevent the rebar from rusting and "blowing out" the form during vibration. In foundation work, rebar is elevated off the ground using "chairs." During installation of rebar, multiple mats or layers are held together with wire twisted around the bars at regular intervals, hoisted into place or assembled in the form. Although rebar usually is cut to length at fabrication shops, custom pieces sometimes are cut on the job with cut-off saws, or oxy-acetylene torches. Before placement begins, the worker cleans rebar and forms of debris. Concrete workers use compressed air blowers, high pressure 12,000 psi water sprayers, magnets, and many other tools to clean debris from forms and rebar.

A monolithic pour is common to mass concrete construction and may take a continuous 24-hours of placement before the form is completely filled. Therefore, placement equipment, such as vibrators, generators, and pumps are completely set up, checked and tested, and the forms are visually inspected for missing parts or other problems before placement begins.

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Conventional Industry Standards

1) Fill material must be added in lifts small enough to allow compaction equipment to attain required density in two to three passes.
2) Fill material moisture content must be maintained at the optimum level to assist the compaction process.
3) Forms must be completely cleaned and free of debris.
4) Forms must be completely oiled.

Key Tasks

1) Excavate site.
2) Add fill materials and compact to specification.
3) Inspect and adjust scaffolding, working surfaces, and fall protection equipment.
4) Read blueprints and mark or confirm location for forms and other components.
5) Assemble tools and forming materials, moving and storing by whatever means is appropriate.
6) Check rigging equipment and rig loads.
7) Designate signaler and check signals for moving materials.
8) Clean, inspect, and oil forms as appropriate.
9) Build/assemble/install forms of all types.
10) Place reinforcement and other embeds and secure them.
11) Perform final inspection of site.
12) Install bracing and supports for forms.
13) Install, inspect, clean, secure, test, and lubricate hoses and concrete conveyance devices.

Workplace Skills, Knowledge, and Aptitudes

1) Lift and move heavy objects.
2) Demonstrate manual dexterity and eye-hand coordination.
3) Work in areas of constricted movement.
4) Estimate material needs.
5) Read rulers and measure length accurately in either U.S. Standard or Metric measure.
6) Read/interpret blueprints for material locations, specifications, and other pertinent information.
7) Choose and use appropriate personal protective equipment.
8) Inspect scaffolding before working on the platform.
9) Work as part of a team.
10) Practice sound electrical safety procedures.
11) Use proper signaling techniques.
12) Set up and use fall protection equipment.
13) Set up and use lasers, levels, and transits.
14) Know forming materials and techniques, including at least metal, wood, and fiberglass.
15) Know rigging techniques for all types of materials.
16) Use hand tools safely and effectively.

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MASS CONCRETE CONSTRUCTION: PLACEMENT

Scenario

Most large concrete placements are conducted continuously and may take several shifts of workers to complete. A large-volume placement will require a convoy of delivery trucks carrying 8-10 cu yds (7.32-9.14 m^3) each. Traffic control is a priority and most projects designate a flag person to direct traffic and keep the concrete trucks moving. Another person signals drivers so two or more trucks can deliver concrete to the hopper at the same time. With multiple trucks delivering at the same time, as much as 20 cu yds (6 m^3) of concrete may be delivered in 15 to 30 minutes. Because quality control is crucial, technicians take truck and placement concrete samples.

Delivery methods include direct discharge from truck chutes, conveyor systems, crane-hoisted hoppers, and high capacity concrete pumps. Where direct discharge is possible, many trucks position themselves around the placement area and deposit the concrete from their chutes. Conveyor systems move concrete from a hopper, while the end of the conveyor is moved to fill the forms. Other projects use high capacity pumps and at least 6" (150 mm) diameter pump lines. Concrete hoses are lubricated with a mixture of cement and water called "slurry" just prior to pumping. Bends of 45 or 90 degrees in pipes are points of high stress and often require two-ton chokers or "comealongs" to hold the line in place. Long vertical sections of concrete pipe are installed with hydraulic gate valves commonly called "guillotines," to reduce the pressures generated during vertical pumping. Alternative placement methods use crane-hoisted hoppers with attached rubber tubes called elephant trunks to drop concrete no farther than 4' - 5' (1.2-1.5 m) from its final resting place.

When placing with a concrete hose, one of the crew is assigned "nozzleman." Working together, the crew moves the heavy 650-pound (~ 300 kg) hose to prevent placing too much concrete in one place. Concrete is pumped in surges, causing the hose to lurch rapidly back and forth. If a crew member is not expecting a surge, he or she can be injured. As one area is filled and a section of hose needs to be removed, the nozzleman drops back to the next section, catches a lull in the concrete surge, and removes the coupling from the last joint. While the rest of the crew continues with the new section, a crew member empties the hose and moves it to a place out of the way. Communication between the concrete crew and the pump or crane operator is critical. Most projects assign someone to communicate with the operator with either two-way radios or hand signals. Signalers understand that entire placement crews depend on accurate, careful signals, so total concentration during crane signaling is necessary at all times.

Concrete is placed in 18" (0.46 m) lifts and consolidated (vibrated) with properly sized vibrators. Vibrator selection depends on rebar size and the size of aggregate within the concrete mixture. During mass placement, high-cycle, 6" (150 mm) concrete vibrators are operated by a three-person crew to consolidate an area of approximately 3 sq ft (1 m^3). The vibrator must be moved constantly, inserted vertically, and removed slowly. Over-vibration separates the cement mortar from the aggregate and causes undue stress on the form work. Under-vibrating leaves air pockets creating "honeycomb." Rebar and embedded steel bonds poorly with concrete if vibration is not performed correctly, weakening the concrete structure. Great lateral pressures are placed against the sides of forms as the level of concrete gets higher and higher. Most projects will have at least one crew person assigned to inspect the forms for signs of failure as the placement continues. When forms fail, they generate sounds of stress as they "unzip" from the bottom to the top. Workers learn to listen for unfamiliar sounds, and must leave the form structure quickly in highly dangerous emergency situations.

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Conventional Industry Standards

1) Placement of uniform lifts of about 18" (0.46 m), level about ± 3" (75 mm) across the length of the lift.
2) Consolidation with correctly sized vibrator so that standard strength is achieved.

Key Tasks

1) Designate signaler, check signals, and use them to move/adjust load.
2) Inspect scaffolding before working on the platform.
3) Check truck gauges to ensure stability of the load.
4) Repair placement system with compatible parts if necessary.
5) Plan and initiate traffic control.
6) Select and use the correct vibrator and vibrator head.
7) Fill form in uniform lifts that are within pressure limits of form. This should be done without dropping concrete.
8) Use vibrator to consolidate concrete.
9) Inspect rigging equipment and rig loads as appropriate.
10) Assist inspector in taking samples as appropriate.

Workplace Skills, Knowledge, and Aptitudes

1) Lift and move heavy loads.
2) Work in areas of constricted movement.
3) Choose and use appropriate personal protective equipment.
4) Inspect scaffolding before working on the platform.
5) Practice sound electrical safety procedures.
6) Use proper signaling techniques.
7) Set up and use fall protection equipment.
8) Know rigging techniques for all sorts of loads.
9) Know limits of forming materials.
10) Read and follow manufacturers' specifications/instructions.
11) Read the sound and feel of the vibrator.
12) Demonstrate manual dexterity and eye-hand coordination.
13) Read gauges and instruments.
14) Work as a member of a team.
15) Recognize sounds of the job and respond appropriately.
16) Perform traffic control duties.

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MASS CONCRETE CONSTRUCTION: CURING AND FORM REMOVAL

Scenario

The steps to finish mass-placed concrete are similar to other concrete placements, so finishing the surface requires identical techniques. However, the hydration process of the greater volume of concrete inside the forms produces more heat. Therefore, finishing must be completed more quickly.

Mass concrete curing is a critical process that requires 10-15 days of continuous surface flooding. In cold weather placements, heated shelters are built around the structure and continuous wetting of both top and side surfaces is performed to cure the concrete evenly. Constant temperature is so crucial to mass concrete, that thermometers are placed on the surface at 15' (4.5 m) intervals, checked every hour, temperatures recorded, and immediate action taken if a problem occurs.

If surface temperatures rise higher than 110° F (43° C), heat is reduced by applying cold water. To enhance curing, burlap is placed next to all exposed concrete surfaces, covered with plastic or insulated blankets, and kept wet constantly during the specified curing period (usually 10-15 days).

Hardware on gang forms is removed only after a crane has secured the form. Once the form is pried and loosened, the crane lifts the gang form and hoists it to the cleaning and storage area. The surface of the form is immediately scraped, and sprayed with a form-release agent, so that it is ready to install in the next location.

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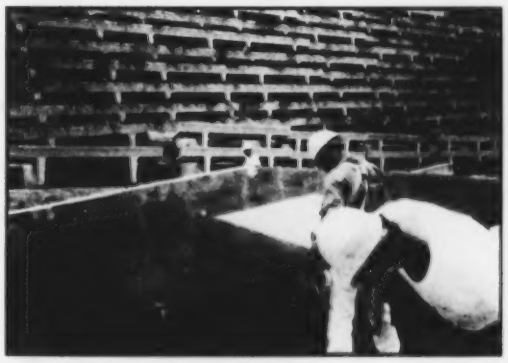
Conventional Industry Standards

1) Forms must be cleaned and oiled so they are reusable.
2) Curing must be maintained within specified temperature limits with excess temperatures not exceeding the tolerances set in project specifications.
3) Surfaces must be free of voids, protrusions, and stains/discoloration. Honeycombing must not exceed one, 1" honeycomb in 64 sq ft (29.26 m^2).

Key Tasks

1) Maintain moisture on surface.
2) Monitor temperature and adjust process accordingly.
3) Initiate and maintain prescribed curing process.
4) Break apart and remove forms.
5) Designate signaler and check signals with operator.
6) Rig and move loads.
7) Clean, oil, and stack forms.



Workplace Skills, Knowledge, and Aptitudes

1) Read gauges.
2) Adhere to time periods.
3) Read/follow instructions.
4) Use hand tools effectively.
5) Understand the chemical reaction that makes concrete.

Workplace Skills, Knowledge, and Aptitudes

Organization of the WSKAs

The following Workplace Skills, Knowledge, and Aptitudes (WSKAs) are comprehensive descriptions of the skills, knowledge and aptitudes required to perform the job duties of a concrete worker. They are arranged in the following categories:

Aptitudes and Abilities
Workplace Basic Skills
Cross-Functional Skills
Occupational Specific Knowledge

The above arrangement allows the reader to identify quickly the group of WSKAs most applicable to their purpose. For example, if the reader is a secondary or post-secondary teacher, he or she might be most interested in comparing the content of their curriculum with the minimum job skills required of a prospective concrete worker. Therefore, he or she might focus on the use of the academic disciplines as described in the section containing workplace basic skills. If the reader is an occupational specific trainer, he or she might find the WSKAs described in the sections containing cross-functional skills and occupational specific knowledge more helpful.

Regardless of the specific use, the reader should review all of the WSKAs to obtain a more complete picture of the academic and psychomotor skills, knowledge, and aptitudes required of a worker to work successfully in the concrete industry.

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Elements of a WSKA

Each WSKA contains the following elements:

- a context
- a mastery performance level
- the content
- references to which job functions the WSKA applies
- references to the key tasks and activities in which the WSKA is included

The Context element describes when and under what circumstances a concrete worker applies the WSKA and provides examples of work processes using that skill, knowledge, and/or aptitude.

The Mastery Performance element identifies how well the WSKA must be performed. The information is useful both to judge priority and as performance criteria for assessment.

The Content element describes teaching exercises and identifies performance demonstrations that will ensure competency.

The Reference elements identify the job function and key task/activity to which a particular WSKA pertains.

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APTITUDES AND ABILITIES

LIFT AND MOVE HEAVY OBJECTS

Context

Construction is physical, heavy work. The work of laborers is among the most physical of all construction work. It involves lifting, moving, and placing very heavy objects and materials. Weight usually exceeds 50 lbs (23 kg) and often exceeds 90 lbs (41 kg). Among the concrete work laborers perform that involves lifting and moving heavy objects are tasks, such as: (a) moving forms; (b) unloading, carrying, and placing reinforcement; (c) moving lumber; (d) placing concrete; (e) mixing concrete; (f) transporting admixtures and curing materials; (g) moving base and sub-grade materials; and (h) other similar activities.

Mastery Performance

1. Laborers will explain the correct steps for lifting and moving heavy objects.
2. Given a load, a laborer will lift and move the load correctly using each step.
3. Given an example of someone else lifting and moving a heavy load, the laborer will point out errors/problems in the technique and suggest how to correct it.
4. Concrete laborers will maneuver wheelbarrows of concrete along narrow, obstacle-filled paths with no spillage and deposit load against existing concrete.
5. Concrete laborers will choose the most efficient method for moving heavy loads of forms, plywood, lumber, retardants, bags of cement and/or admixtures.
6. Laborers will smoothly lift, balance and carry, three 2" x 4" x 16' pieces of lumber a distance of 50' (or 15 m) and set them down on dunnage.

Content

Method One

1. Size-up a load (weight, size, and shape) to ensure you can handle it.
2. Place feet close to object and spread them apart about as wide as your shoulders.
3. Bend at the knees and find handholds.
4. Keep your back straight (in line with hips) and tuck your chin so your head is in line with your back.
5. Lift by standing up, putting the load's weight on your knees and thighs. Lift the load straight up. Keep load close to your body.
6. Turn by changing foot position and carry the load close to your body.
7. Set load down using legs to support weight.

Method Two

1. Raise bag upright.
2. Put one knee against the bag as you kneel on one knee.
3. Pull the bag up to your leg.
4. Transfer the bag to edge of the other knee.
5. Stand upright, moving the bag up to your body.
6. Carry the load close to your body.

Reference

Job Functions	Sample Tasks and Activities
All	Operate soil compaction equipment Assemble/install forms at appropriate location Install/inspect/secure concrete transport equipment Place, rig, and move materials

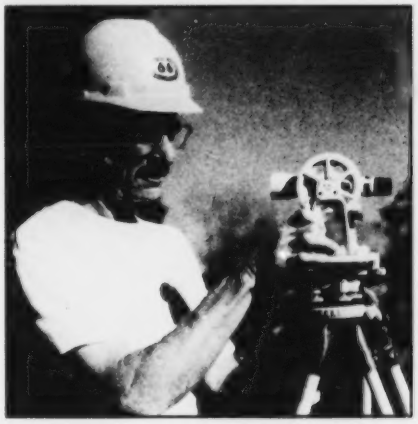
DEMONSTRATE MANUAL DEXTERITY AND EYE-HAND COORDINATION

Context

Concrete workers must use strength combined with manual dexterity and eye-hand coordination to perform much of the work they do. In concrete work, dexterity, coordination, and strength are required to: (a) hold and use hand and power tools to achieve the required grade tolerance of the subsoil and base for horizontal placement; (b) adjust and use the laser or level; (c) manipulate the power screed and the power trowel; (d) achieve the specified surface with floats and hand-held steel trowels; and (e) manipulate the vibrator to achieve optimal material consolidation.

Mastery Performance

1. Given any of a number of tools used in concrete work, the laborer will demonstrate sufficient hand strength, manual dexterity, and eye-hand coordination to operate correctly the machine or use the tool.
2. Given the tasks of a concrete worker, the trainee will receive an acceptable score on a standardized test of manual dexterity, such as the Minnesota Rate of Manipulation tests or the revised Toucheck/Brown eye-hand-foot coordination samples.



Content

1. Demonstrate, explain, and practice tool and equipment use to work on coordination and dexterity in mock-up situations.
2. Work with strength, flexibility, dexterity, and eye-hand exercises, including both gross and fine motor movement.

Reference:

Job Functions	**Sample Tasks and Activities**
All	Layout and square area Remove/install/assemble all forms at proper location Use lasers/levels/transits to mark/check installation location Install and service concrete transport equipment Compact subgrade Install reinforcement and embeds Evenly distribute concrete close to final location Screed materials Install barricades Direct traffic Rig materials Use signals to move loads/control materials

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WORK IN AREAS OF CONSTRICTED MOVEMENT

Context

Some work associated with concrete involves moving, installing materials, carrying loads, and other efforts in cramped, small areas that dramatically restrict range of motion. Examples of areas of constricted movement include work on staged, jack, and swing scaffolding and work inside vertical forms. Situations in concrete work where constricted movement is experienced include the: (a) difficult footing and confined spaces normally encountered in placing concrete slabs; (b) vertical body space available when placing reinforcement and concrete in walls and columns; (c) body and foot space available on all types of scaffolding; and (d) space for tool and arm movement in many locations.

Mastery Performance

1. Exhibit no signs of claustrophobia or exhibit excellent control in mock-up work situations that include restricted movement.
2. Demonstrate sufficient strength and dexterity to use tools to complete work to quality and on schedule in constricted space.

Content

1 Discuss situations and types of constricted movement in concrete work in construction.
2. Discuss problems, dangers, and strategies for dealing with work situations.
3. Demonstrate technique for some types of identified situations.
4. Practice on mock-ups that illustrate job settings. Use a variety of working surfaces and situations including at least stepping among/between reinforcement in horizontal placement; horizontal finishing; vertical reinforcement placement; vertical concrete placement; vertical vibration; all types of form stripping; and working on all types of scaffolding.

Reference

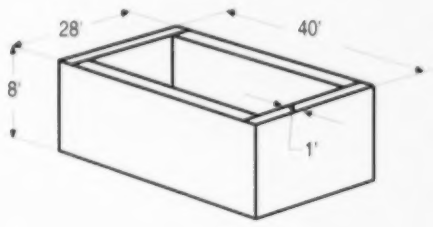
Job Functions	**Sample Tasks and Activities**
All	Assemble forms tightly with minimal leakage Install reinforcement of correct type in appropriate place Install waterproof membrane/vapor barrier Install and inspect concrete transport equipment Install form bracing Place concrete in all settings Consolidate concrete using vibrator and appropriate head Clean forms prior to placement Remove forms Strike-off concrete Edge and joint surfaces

WORKPLACE BASIC SKILLS

CALCULATE VOLUMES OF VARIOUS SHAPES

Context

Concrete workers find volume measures for objects of many sizes and shapes. For example, work involving volume calculations includes at least the following: (a) estimate the amount of concrete needed to fill forms of all types and shapes; (b) calculate the number of cubic yards or cubic meters of earth that must be moved to excavate or fill a site; (c) determine the progress on excavation and fill projects; (d) find reinforcement needs; (e) determine air space and ventilation requirements; and (f) plan or complete other similar operations.



Mastery Performance

1. Given specific objects, concrete workers will find volumes from linear measurements. Volumes must be correct within 1/2 cu yd (0.4 m^3), with the tolerance always in the direction of + 1/2 cu yd (0.4 m^3).
2. Given an object, the concrete worker will demonstrate how to "break" the object into manageable shapes to use formulas and find capacity.
3. Given volume formulae, the concrete worker will match the formulae with the appropriate shape.

Content

1. Demonstrate, explain, practice, and find volume of squares and rectangles.
2. Demonstrate, explain, practice, and find volume of spheres and hemispheres.
3. Demonstrate, explain, practice, and find volumes of cylinders.
4. Demonstrate, explain, practice, and find volumes of pyramids.
5. Match formulae for volume calculation of objects to various shapes.
6. Work with and convert cubic units of measure, in both metric and U. S. Standard measure.
7. Illustrate how to break objects into shapes from which one can find volume measures.
8. Discuss work tasks where volume calculation is used.

Reference

Job Functions	**Sample Tasks and Activities**
Horizontal Preparation	Excavate materials
Horizontal Placement	Estimate concrete needs
Vertical Preparation	Estimate forming and reinforcement material
Vertical Placement	Order appropriate materials
Mass Preparation	Place reinforcement and embeds at correct location
Mass Placement	Prepare/compact base and subbase

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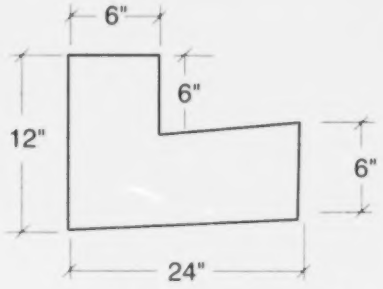
CALCULATE AREAS OF VARIOUS SHAPES

Context

Concrete workers must calculate area in many components of their work. Among the tasks and activities for which area calculation is used are: (a) determine the size of an area to find how much forming material (or how much more forming material) is needed; (b) find the area of a poured surface to determine how much curing, cleaning, or protective material to cut, mix and/or apply; (c) calculate the amount of surface to estimate time requirements to complete tasks; and (d) find areas to determine installation adjustments for environmental issues such as temperature or humidity problems.



Mastery Performance

1. Given specific objects a worker will find areas from linear measurement, correct within ± 2 sq ft (0.6 m^2).
2. Given an area to cure, a worker will compute adequate liquid or spray to cover with a 2' (0.6 m^2) overlap around entire perimeter of concrete area.
3. Given an object, the worker will demonstrate how to "break" the object into manageable shapes to use formulae to find area measures.

Content

1. Demonstrate, explain, practice, and find area of square and rectangles.
2. Demonstrate, explain, practice, and find area of circles and cylinders.
3. Demonstrate, explain, practice, and find area of triangles.
4. Demonstrate, explain, practice, and find area of unusual shapes; illustrate how to break objects into shapes from which one can find area.
5. Match formulae for area calculations of objects to different shapes.
6. Work with and covert square measures in both metric and U.S. Standard measure.
7. Discuss work tasks where area calculation is used.

Reference

Job Functions	**Sample Tasks and Activities**
Horizontal Preparation	Read/follow manufacturers' mix instructions
Horizontal Curing	Estimate material needs
Vertical Preparation	Install reinforcement and embeds
Vertical Curing/Form Removal	Build openings in forms
Mass Preparation	Apply curing and protective materials
Mass Curing	Assemble/build forms
	Monitor work progress
	Light work area
	Establish traffic control

USE RATIO AND PROPORTION MEASURES

Context

Concrete workers use ratio measures to mix materials, check on the quality of materials to install, and predict amounts of concrete needed. For example, they combine admixtures, salt mixtures, color, and fiber into cementitious materials on a ratio basis. Likewise, workers mix curing, protective, and cleaning agents in ratios according to manufacturers' instructions. Even checking the quality of concrete requires understanding and using ratios as workers check the cement strength/concentration. Concrete workers who operate compaction equipment must know ratios when they mix 2-cycle oil with fuel for various equipment.

Mastery Performance

1. Given instructions for adding to or mixing materials for concrete work, the worker will identify, describe, and mix the materials according to ratio correct within 1 part of exact.
2. Hand mix concrete, if needed, using appropriate ratio of cement, sand, and water.
3. Given a problem involving ratios, the worker will work the problem and find a correct answer 8 out of 10 times, including performance demonstrations.
4. Given instructions involving ratios and mixes, the worker will correctly identify both the mix measures and mix tolerances every time.
5. Given form dimensions and using ratios, workers will perform calculations and predict the concrete needed, within + 1/2 cu yd (0.4 m^3).

Content

1. Describe concepts of proportion and ratio.
2. Demonstrate how to proportion with containers.
3. Review units of volume measure.
4. Identify proportions and tolerances in sets of instructions.
5. Demonstrate and explain how to read ratio and proportions.
6. Describe some of the problems (and how to identify them) that occur when the various types of proportional mixes associated with cement/concrete work are mixed and applied incorrectly.
7. Demonstrate situations where ratios are used; show and explain how to do it.

Reference

Job Functions	**Sample Tasks and Activities**
All	Locate grade stakes Monitor excavation and fill processes Layout and square area Mix curing materials Add/incorporate admixtures Estimate material needs

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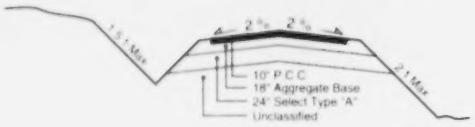
USE PERCENTAGE MEASURES

Context

Concrete workers use percentage measures in much of their work. For example, concrete workers check the quality of materials before installation by noting the strength of the cementitious materials, the volume of air, and the amount of water in the mix by working with percentages. Likewise, work is estimated and monitored/tracked by using percentages. In addition, to promote run-off and drainage of water or other liquids from the surface, concrete and the underlying sub-grades are constructed with a slope expressed in percentages of grade. Similarly, percentages are used to calculate volume discounts of purchased materials, buying tools and/or equipment on sale, or when leasing equipment such as pump trucks by the hour.



Mastery Performance

1. Given a problem involving percentages, the worker will work the problem and find the correct answer within ± 1%, 8 out of 10 times.
2. Given a percentage measure, the worker will explain how it applies to the work situation.

Content

1. Describe and explain concept of percentage.
2. Review units of measure and how they relate to percentages.
3. Illustrate how to find percentages as (a) part of the whole; (b) as a part; or (c) as a percentage and work a number of practical problems of each type.
4. Describe work related situations where percentages are used, including as a minimum material/tool pricing and tracking the percentage of a task that is completed.
5. Demonstrate, explain, and practice using percentages of slope to calculate vertical rise or fall.
6. Create problems from the work place to practice.

Reference

Job Functions	**Sample Tasks and Activities**
All	Monitor work process Read gauges/check material quality

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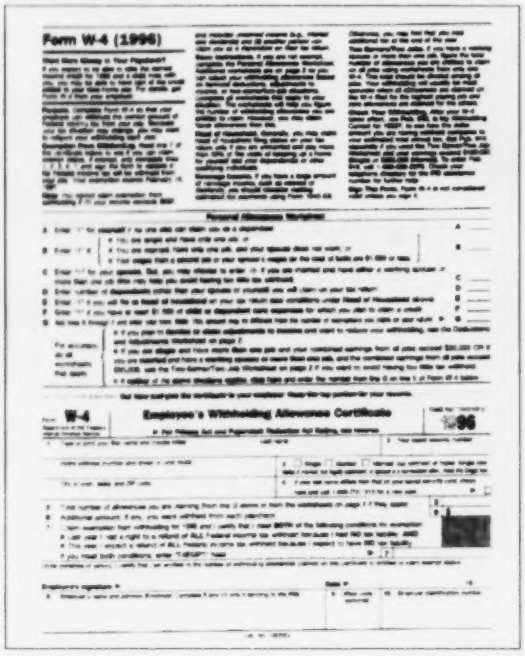
COMPLETE EMPLOYMENT FORMS

Context

Concrete workers work on projects of limited duration and, therefore, work on scores of projects and for dozens of contractors. Consequently, workers frequently complete an array of employment related forms as they move from employer to employer and project to project. Among the forms they must complete are the following: tax forms, insurance forms, citizenship forms, employer records/applications, and occasionally, accident report forms.


Form W-4 (1996)

W-4 Employee's Withholding Allowance Certificate 1996

Mastery Performance

1. Given an employment form, such as a withholding form or an employer's insurance form, the worker will read, interpret, and correctly complete each question or entry.
2. Given a set of frequently asked questions, the worker will read, interpret, and explain the question and provide the requested answer.

Content

1. Identify the types of forms workers typically encounter.
2. Discuss purposes and uses of typically encountered forms.
3. Discuss types of "vital" information usually requested on forms such as social security number, emergency contacts, and so forth and assist trainee to learn their own information.
4. Read/interpret questions typically asked on employment-related forms.
5. Provide appropriate marks or short answers, as required, to commonly asked questions.
6. Define vocabulary and key words of frequently asked questions.

Reference

Job Functions	**Sample Tasks and Activities**
All	All, as the worker begins employment with each employer

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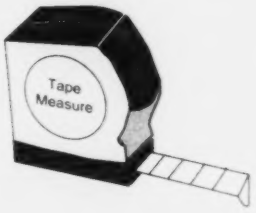
READ RULES AND MEASURE LENGTH IN U.S. STANDARD OR METRIC UNITS

Context

Concrete workers routinely mark, measure, and check distances in concrete work. Linear distance measurements are used to: (a) position and space reinforcement; (b) build/check the location, height, width and length of forms, walls, and/or slab locations; (c) mark, establish, and check grade stakes; (d) monitor and/or excavate base materials; (e) estimate material needs; and (f) determine allowable tolerances and quality standards for work.

Mastery Performance



1. Given a measurement value, the worker will read the unit of measure exactly, 9 out of 10 times.
2. Given specific objects to measure, the worker will measure linear distance correctly within ± 1/8" (3 mm).
3. Given a unit of measure, the worker will convert the unit to other fractions or metric measures, correct within ±1/8" (3 mm).
4. Given a measurement to transfer from one object to another, the worker will mark the distance on the object, correct to within ± 1/8" (3 mm).
5. Given blueprint or verbal measurements, the worker will convert millimeter measures to meter measures 10 out of 10 times.
6. Given metric versus standard measuring instruments, the worker will determine, 10 out of 10 times, whether markings are presented in feet, inches, millimeters, meters, and/or tenths or hundredths.

Content

1. Read dimensions of units of measure on measuring rods, rulers, and/or tapes.
2. Convert (reduce or expand) fractions to other equivalent fractions and/or convert millimeters to equivalent meters.
3. Change fractions to mixed or whole numbers and change whole and mixed numbers to fractions.
4. Transfer measurements from one object to another with a tape or rule.
5. Discuss conventions for location of mark when measuring.

Reference

Job Functions	**Sample Tasks and Activities**
Horizontal Preparation	Assemble and install forms at appropriate height
Horizontal Placement	Clear and excavate site
Vertical Preparation	Backfill and compact
	Install reinforcement
	Install pump hoses and pipe
	Estimate/order materials
	Install grade stakes and check grade
	Test slump
	Layout and square area

READ/INTERPRET MATERIAL SAFETY DATA SHEETS

Context

Concrete workers use or handle many chemicals and potentially hazardous products during a construction project. Further, with rapidly changing technology, new products are introduced constantly. Federal law requires that all products with potential ill health effects be accompanied by a Material Safety Data Sheet (MSDS) that describes the material's properties, handling requirements, first aid, and installation instructions. Further, the MSDSs must be available at the work site so that workers can inspect them during working hours. However, MSDSs are not uniform and often are difficult to read, especially for finding and interpreting specific information. Often the MSDSs are both the best and only source of information for material use and health protection. Typical products workers handle in concrete work that have MSDSs include concrete additives, curing and coating compounds, acids, cleaning agents, cement, and lime.

Mastery Performance

1. Given a question about a potentially hazardous material, the worker will be aware of the MSDSs and the regulations governing their use.
2. Given the name of a potentially hazardous material, the worker will correctly find the appropriate MSDS.
3. Given a question about a potentially hazardous material and its MSDS, the worker will correctly find the appropriate information.
4. Given a question about potentially hazardous material and its MSDS, the worker will read and correctly interpret the data of concern contained in the MSDS.

Content

1. Explain purpose, background, and rules governing MSDSs.
2. Define terms included in MSDSs.
3. Determine how to find MSDS sections.
4. Identify information contained in various sections.
5. Match MSDSs to material information of any type.
6. Read/interpret technical terms.
7. Understand how to apply information from an MSDS in practice.
8. Locate critical information.

Reference

Job Functions	**Sample Tasks and Activities**
Horizontal Preparation	Clean, oil, and stack forms
Horizontal Placement	Mix curing materials
Horizontal Curing/Form Removal	Apply curing material
Vertical Preparation	Add/incorporate admixtures
Vertical Placement	Add retardants and/or accelerators to concrete
Vertical Curing/Form Removal	
Mass Concrete Preparation	
Mass Concrete Placement	
Mass Concrete Curing/Form Removal	

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READ/INTERPRET BLUEPRINTS, PLANS, OR PRINTS

Context

Concrete workers perform much of the preparation work for any phase or task on a concrete construction project. The process means that workers and their supervisors must read, interpret, and use the set of prints to locate, mark, form, and build all types of structures. Among the tasks concrete workers perform from plans are: (a) locating, placing, and checking grade stakes; (b) locating and squaring structures; (c) locating objects, columns, walls, foundations, and so forth; (d) ordering, storing, and stocking materials; (e) preparing building areas, building objects, and structures; (f) installing materials; (g) estimating materials; (h) landscaping; and (i) installing finishing materials.

Mastery Performance

1. Given a set of prints and an information request, a concrete worker will locate any given structure, object, material, or specification with a view and/or text that provides the required data.
2. Given a set of prints and an object location need, the worker will locate the correct information from the appropriate print and transfer it to the site with an accuracy of ± 1/4" (6 mm).
3. Given a symbol or abbreviation, the worker will correctly interpret the information.
4. Given a set of prints, the worker will read the dimensions and/or use scale to find dimension, correct to ± 1/4" (6 mm).

Content

1. Read index of plans and specifications to locate information.
2. Interpret symbols and abbreviations.
3. Understand and follow rules of prints, specifications, and addendum.
4. Find information in plans and specifications.
5. Read dimensions accurately.
6. Use scale to find dimension and location.
7. Transfer information from plans to site.
8. Use plans to estimate and/or order correct type and amount of materials.
9. Read and interpret views and types of drawings
10. Use notes and specifications to determine materials requirements.
11. Use references to locate information and/or correct view.

Reference

Job Functions	**Sample Tasks and Activities**
Horizontal Prep/Placement	Assemble and install forms at proper locations
Horizontal Curing	Install reinforcement and embeds at proper locations
Vertical Prep/Placement	Add/incorporate admixtures into concrete
Vertical Curing/Form Removal	Mix curing materials
All Mass Concrete	Read gauges/check concrete before placement

CROSS-FUNCTIONAL SKILLS

CHOOSE AND USE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT

Context

Concrete workers need and use personal protective equipment (PPE) to help prevent chronic and/or serious injury to various body parts like skin, feet, eyes, ears, hands, and head. The specific type of equipment a worker chooses and uses depends on the particular task being performed and the type of hazard/safety situation that might be encountered. For example, workers placing horizontal concrete slabs typically wear rubber boots for foot and leg protection, while workers preparing to place a slab or stripping forms more often wear steel-toed leather boots. Similarly, eye protection might not be necessary for horizontal or vertical finishing, but is appropriate for placement and curing. Hard hats are a must for all concrete work.

Mastery Performance

1. Given a concrete work task, the worker will identify the correct PPE to wear.
2. Given any PPE for concrete work, the worker will explain the selection of correct type, class, and size of PPE and demonstrate how to fit, adjust, and use the PPE appropriately.

Content

1. Review types of eye protection and match each to the tasks and safety hazards for which it is used.
2. Demonstrate correct fit, use of each type, and care of PPE.
3. Review types of ear protection and match each to the tasks and safety hazards for which it is used.
4. Review types of boots and match each to tasks and safety hazards for which it is used.
5. Review types of hard hats and match each to tasks and safety hazards for which it is used.
6. Demonstrate correct fit, adjustment, use of each type, and care of PPE.
7. Review types of gloves and match each to the tasks and safety hazards for which it is used.
8. Choose appropriate clothing for concrete work.

Reference

Job Functions	**Sample Tasks and Activities**
All	All

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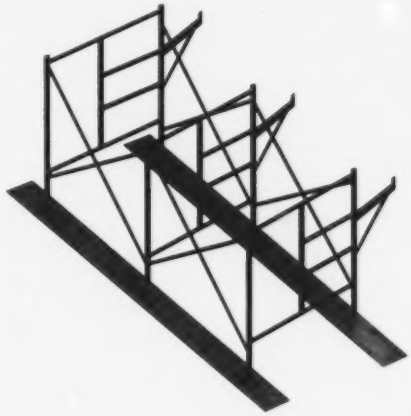
INSPECT SCAFFOLDING BEFORE WORKING ON PLATFORM

Context

Scaffolds are a primary working surface and shoring method for workers who prepare and place concrete in flatwork, vertical, and mass situations. While scaffolds enable workers to get much closer to their work, reduce fatigue, and improve productivity, improper erection of scaffolds causes many accidents and accounts for large numbers of safety citations.



Mastery Performance

1. Given work to be performed on a scaffold, a concrete worker will perform a basic safety check of all points and ensure the scaffold conforms to safety requirements before ascending or beginning work.
2. Given a scaffold with a defect, the worker will identify both the problem and suggest the criteria that must be met to correct the problem in 10 out of 10 instances.
3. Given a scaffold, the worker will ensure scaffolds are plumb to within 1/4" (6 mm) over 10 vertical feet (3.05 m).
4. Given a scaffold access problem, workers will choose the most efficient access method and identify 10 out of 10 OSHA safety requirements for ladders and stairways.
5. Identify and test weakened scaffold planks with splits, checks, cracks, warps, bends, cuts, and other defects 10 of 10 times.
6. Ensure that scaffolds are protected from compressive and tensile forces through structural ties located at least 21' (6 m) vertically, and 30' (9 m) horizontally to avoid tipping and subsequent scaffold failure.

Content

1. Check planks for defects.
2. Ensure planks are secured, cleated, and/or overlapped at least 12" (305 mm).
3. Ensure toe boards are in place on open edge of platform.
4. Ensure the scaffold is at least 10' (3 m) away from exposed or energized electrical wire.
5. Check that winds do not exceed 25 mph (40 km/hr).
6. Ensure that ladders are installed and secured for access and egress.
7. Ensure that scaffolds are tied-off (into structure) every 3 frames vertically and every 2 frames horizontally.
8. Check scaffolds for level, plumb, and that they are installed on mud sills.
9. Ensure that the load limit is not exceeded.
10. Ensure overhead protection if trade workers are working overhead.
11. Ensure guardrails (top/mid-rail) are installed and attached at prescribed heights.
12. Ensure that all bracing is attached and secured (clipped, wired, etc.).

Reference

Job Functions	**Sample Tasks and Activities**
All Vertical and Mass Concrete Work	Install/Inspect concrete transport equipment
Some Horizontal Concrete Work	Assemble and attach forms at proper height
	Assemble all required scaffolds

COMPREHEND AND FOLLOW SEQUENTIAL STEPS

Context

Concrete workers must follow sequential steps to complete a number of work tasks. For example, one follows specific steps when placing concrete, starting with placement, and then consolidation and strike-off. Similarly, mixing and applying curing materials or cleaning agents also uses sequential steps, typically combined with specific real time requirements between coats and/or materials. The whole process of horizontal, vertical, and mass concrete work is a detailed sequential process from site preparation to project completion.

Mastery Performance

1. Given any of the sequential tasks for concrete, the worker will describe and perform the tasks, in the correct order and time frames.

Content

1. Discuss sequences people use in their everyday lives; discuss consequences of not following sequence.
2. List the sequences involved in concrete work.
3. Demonstrate and explain sequences in concrete work.
4. Discuss and illustrate consequences of ignoring or not following sequences in work.
5. Demonstrate and discuss a variety of sequencing activities. Use all types of exercises including tools, daily activities, and work.
6. Demonstrate, discuss, use, and remember sequences of concrete work.

Reference

Job Functions	**Sample Tasks and Activities**
All	Finish concrete surfaces Mix curing agents Install reinforcement and embeds Apply admixtures Plan, establish, and direct traffic Install, inspect, test, and lubricate concrete equipment Consolidate concrete with vibrator and correctly sized head

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PRACTICE SOUND ELECTRICAL SAFETY PROCEDURES

Context

Concrete workers encounter electrical hazards on almost every work site. Typically construction sites use temporary hookups and wiring. In addition, sites have wet conditions and many exposed metal surfaces, and suffer the deteriorating effects of heat, cold, and caustic materials. Particular concrete work hazards include: (a) wet conditions from concrete and curing materials; (b) abrasive/sharp surfaces like forms, rebar, aggregate, and finished concrete that damages wires; (c) high voltage wires in close proximity; (d) tools like vibrators that may not be double-insulated and that even when used correctly are subjected to damaging conditions; (e) heavy equipment moving around temporary wiring that may cause damage; and (f) debris.

Mastery Performance

1. Concrete workers will demonstrate correctly how to check wires for damage and identify problems each time.
2. Concrete workers will identify types of Ground Fault Circuit Interrupters (GFCIs), demonstrate how to check them, and explain how and why they are important.
3. Given a typical construction site, the concrete worker will identify correctly at least a half dozen typical electrical hazards.
4. Given three electrical concrete tools, concrete workers will assess the power requirements of each tool, and choose the correct length and wire gauge of the cord for each tool.

Content

1. Illustrate use, check, and discuss types of GFCIs.
2. Demonstrate, illustrate, and practice how to check wires for frayed/damaged insulation, sound connector, continuity/broken wires, and grounding.
3. Demonstrate, illustrate, and practice how to check plugs for damage, water-tightness, and strain relief.
4. Discuss strategies for eliminating wet and metallic locations where tools must be used.
5. Demonstrate unplugging tools before changing parts to avoid "quick starts."
6. Demonstrate how to check tool for double insulation and sound casings.
7. Illustrate and discuss appropriate heavy equipment position with regard to energized, and especially, high voltage power lines. Discuss warning signs regarding electrical danger.
8. Discuss, demonstrate, and practice rules for inspecting, marking, and documenting your inspection of electrical wires.
9. Demonstrate how to use manufacturers' faceplates to help determine wire gauge and length needs for tools.
10. Illustrate and discuss how to check for energized wires/circuits.
11. Demonstrate how to look for and use grounded plugs and receptacles.

Reference

Job Functions	**Sample Tasks and Activities**
All	Consolidate concrete with vibrator and correctly sized head
	Rig and move materials
	Install/inspect concrete transport equipment
	Install forms of all types

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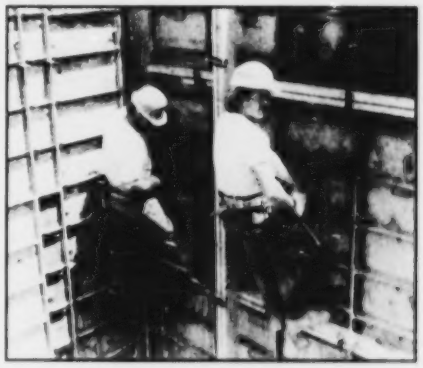
SET UP AND USE FALL PROTECTION EQUIPMENT

Context

Mass and vertical concrete work, and even high rise horizontal placement, involves the risk of falling from scaffolding and structures. The risks of working on scaffolds are real and are increased because concrete work involves manipulating large and heavy equipment, such as concrete buckets, pipes, and hoses from those surfaces. Many times an operator will not be able to see the work area or surface, except for the signal person who directs the movement. In addition, the surfaces are even more dangerous because concrete is wet and slick. However, recent advances in materials and equipment for fall protection can provide a safety margin on the job.



Mastery Performance

1. Given fall protection equipment, the concrete worker will demonstrate exactly how to use it, including donning the equipment, tying-off, and moving. The worker also will describe the limits and tolerances of the equipment.
2. Concrete workers will inspect equipment and correctly point out sound and defective components and equipment.
3. Workers will illustrate how to find good anchorage and the rating of equipment.

Content

1. Discuss all types of fall arrest systems.
2. Illustrate and discuss components of arrest systems like D-clips, snap hooks, shock absorbers, and anchorages.
3. Illustrate types of safety belts and how to wear, adjust, tie-off, check, and use one.
4. Practice correct use of safety belts.
5. Illustrate types of safety harnesses and safety lifelines. Show how to wear, adjust, tie-off, check, and use one.
6. Practice correct use of safety harnesses.
7. Practice correct use of the lanyard.
8. Illustrate types of fall protection equipment and demonstrate how to check, adjust, and attach one.
9. Practice use of the lifeline.

Reference

Job Functions	**Sample Tasks and Activities**
Horizontal Preparation	Set-up/inspect scaffold
Vertical Preparation	Install access and egress to scaffold
Mass Preparation	Rig and move materials
Horizontal Curing/Form Removal	Install/assemble forms for correct locations
Vertical Curing/Form Removal	Install/attach reinforcement and embeds
	Cure and remove forms

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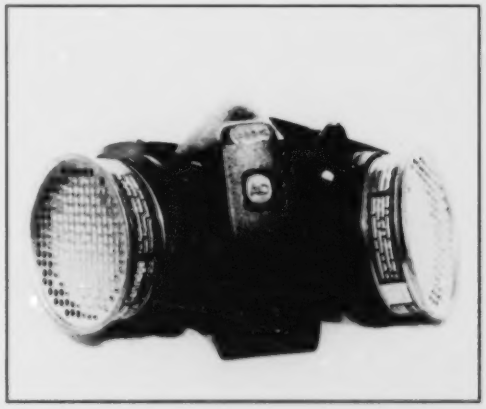
WEAR PROPER DUST MASKS AND/OR RESPIRATORS

Context

Construction sites are dirty, dusty, and contain many hazardous materials. Often concrete workers wear masks or respirators to complete some of their tasks. For example, preparing existing concrete surfaces for additional placement (such as a construction joint) often involves removing excess concrete with a pneumatic pavement breaker or chipping hammer. This operation creates a substantial amount of concrete dust. Workers wear proper dust masks to protect their lungs. Even more important, many admixtures, curing/sealing compounds, and cleaning agents contain materials that are health hazards and require that workers wear air purifying respirators to protect their lungs and other organs.



Mastery Performance

1. Given a concrete task and possible respiratory protection, the worker will match the proper respirator or mask to the hazardous task every time.
2. The concrete worker will demonstrate correctly how to inspect and don an air purifying respirator, and choose appropriate filters every time.
3. The concrete worker will clean, sanitize, and replace defective respirator parts correctly every time.
4. The concrete worker will gather information from at least 12 MSDSs or labels, identify and don appropriate respirators that match the hazard.

Content

1. Discuss air hazards on the concrete construction site, including at least cancer-causing material, dust, chemical vapors, and welding fumes.
2. Illustrate, explain, and match types of respirators/masks to hazards.
3. Demonstrate how to size, inspect, don, and adjust masks and respirators. Emphasize type of cartridges and both positive and negative pressure checks.
4. Disassemble, name parts, and reassemble negative pressure air purifying respirator.
5. Practice inspecting, donning, and checking the mask and respirator.
6. Illustrate and discuss how to doff and clean respirators.
7. Practice how to doff and clean the respirator.

Reference

Job Functions	**Sample Tasks and Activities**
Horizontal Preparation	Remove organic matter
Vertical Preparation	Fill and compact base and subbase materials
Mass Preparation	Mix curing materials
Horizontal Curing/Form Removal	Apply curing and cleaning materials
Vertical Curing/Form Removal	Mix admixtures according to specification
	Clean debris from rebar before placement
	Cut rebar and I-beams
	Grind and/or break concrete
	Sweep dust and debris
	Clean forms with compressed air
	Hand mix concrete
	Perform bush hammer work

USE PROPER RIGGING AND SIGNALING TECHNIQUES

Context

Concrete workers use heavy equipment to lift and hoist materials to placement locations. Equipment operators are located far from the placement location and often cannot see the work area. Therefore, operators must rely on a signaler to safely direct the movement of concrete and other materials. Signalers must understand how the speed, direction, and movement of the hoisting equipment will affect the load and its position. Concrete workers who rig material must know the weight of the load, capacity of lifting cables, and limitations of lifting hardware. Signals are given verbally using two-way radios, nonverbally with hand signals, and sometimes with both. Signals must be correct, standardized, timely, and accurate, or workers can be killed or injured and structures can be damaged. Further, it is critical that only one signaler gives signals to the operator, and that the signaler is positioned to see the work and be seen by the operator.

Performance Mastery

1. Given a test of international voice or hand signals, the worker will identify and use the correct signal to direct the load every time.
2. Given a construction work site and equipment location, the worker will identify the correct location to see and be seen as the signaler.
3. The concrete worker will determine the weight of 10 commonly hoisted materials used in concrete work to within 100 lbs (45 kg).
4. The concrete worker will determine the lifting capacity within 100 lbs (45 kg), of at least three chokers and three slings without reference to charts, tables, or other written data.

Content

1. Illustrate, describe, and use international hand signals to move load.
2. Illustrate, describe, and use international voice commands to move load.
3. Demonstrate how to work out command use with the equipment operator.
4. Discuss emergency rigging situations and how to react.
5. Discuss vantage points (locations), why they are important, and how to select them.
6. Locate/choose vantage points for a variety of loads.
7. Discuss and illustrate the effect of equipment movement on the load. Discuss weight of load, directions, wind, inertia, and ratio of distance moved.
8. Discuss specific safety hazards such as "over flights" and proximity of load to workers.
9. Discuss rules for designating signalers and how to deal with infractions.
10. Learn rigging techniques and lifting capacities of rigging equipment, as well as weights of materials.

Reference

Job Functions	**Sample Tasks and Activities**
Horizontal Prep/Placement	Rig and move all concrete materials
Mass Prep/Placement	Designate signaler and check signals with operator
Vertical Prep/Placement	Move/transport concrete to placement locations
Mass Placement	Select appropriate lifting equipment

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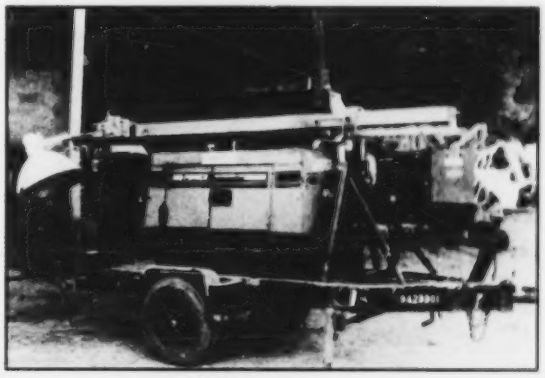
SET UP AND MAINTAIN LIGHT SOURCES

Context

Working at night or in an enclosed area requires the set up and maintenance of artificial light sources. Examples where night shifts are necessary include high volume daytime traffic areas and/or regions where daytime temperatures are too high for concrete placement. Without proper lighting, communication is difficult, accidents are likely, and production is low. Artificial light includes electric flood lights located on trees or supporting posts, lights on cranes or other equipment, and portable light plants.



Mastery Performance

1. Fuel, maintain, and ensure operation of light plants or portable electrical generators during entire work shift.
2. Set up double light plants 50' (17 m) apart with single lights pointing towards each other, angled at 45°-90° from roadway and 22° down toward surface.
3. Chock or block light plants and transport them safely without any damage or contact with hazards like power lines.
4. Illuminate walking and working surfaces so they can be clearly seen.
5. Direct lights away from operators performing hoisting duties every time.
6. Given an unlit work area, choose and set up an adequate lighting system to provide 50 watts for every 100 sq ft (30 m^2).
7. Select and use adequate power cords and install GFCI every time.
8. Follow OSHA electrical standard 10 out of 10 times.

Content

1. Read lighting plans to determine number and location of lights.
2. Select appropriate lighting amperage for a given area.
3. Discuss the physics of electricity and hazards of electrical shock.
4. Note the voltages contained in overhead power lines and determine safe distances that must be maintained.
5. Read and use portable light plant operation manual.

Reference

Job Functions	**Sample Tasks and Activities**
All	All concrete work at night All concrete in unlit spaces

PERFORM TRAFFIC CONTROL DUTIES

Context

Construction sites are normally very congested areas. Within the job site, limited space is available, there are multiple storage areas for construction materials, and the frequent movement of heavy equipment and delivery trucks make traffic control important to both production and safety. When the construction site is located in a major urban area, each of the above problems is multiplied. On sites that adjoin or are on public roads and highways, traffic safety for the public and for the workers becomes crucial. All concrete workers are required to perform some level of traffic control. Tasks range from helping a concrete truck back up to a hopper to directing the set up of traffic signage/barricades in busy intersections.

Mastery Performance

1. Given a traffic control situation, a concrete worker will identify the correct flag or paddle signal to oncoming traffic every time.
2. Given a mock site and proposed traffic circulation pattern, a concrete worker will identify the best possible circulation pattern to provide public and worker safety and maintain production every time.
3. Given a mock site and proposed traffic circulation pattern, a concrete worker will identify the correct location for signs and barricades every time.
4. Concrete workers performing traffic control will place barriers, barricades, signs, signals, and other traffic control devices safely and at the correct distance and orientation.

Content

1. Discuss, demonstrate, and practice signaling with flags and paddles.
2. Demonstrate traffic control strategies that provide for public safety, worker safety, and production.
3. Discuss, review, and demonstrate knowledge of the Uniform Traffic Control Code or state equivalent for flagging and signage requirements.
4. Understand/adopt traffic control planning and set-up, given real-life scenarios.

Reference

Job Functions	**Sample Tasks and Activities**
All	Read/interpret blueprints for locations and material specifications Move and store materials near work Move concrete to placement location Direct and control oncoming work place or public traffic Place traffic control devices correctly within known specifications Communicate clearly and concisely on two-way radios Set-up barricades as needed at the work site

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OCCUPATIONAL SPECIFIC KNOWLEDGE

IDENTIFY COMMON PROBLEMS ASSOCIATED WITH CONCRETE WORK

Context

Concrete is a material affected by many variables, but with predictable results. Among the problems workers encounter and try to eliminate, correct for, or avoid are the following: (a) inadequate strength gain; (b) excessive bleeding (too much water on surface as aggregate settles); (c) excessive curling (the top of the slab shrinks more that the bottom as it dries); (d) scaling (surface comes off in crumbles or slivers); (e) dusting (surface develops chalky surface upon drying); and (f) random cracks or map cracking (hairline surface cracks). These problems are preventable through training and care.

Performance Mastery

1. Given a common problem, the concrete worker will correctly identify the problem and indicate at least three valid reasons that might have caused it.
2. Given a typical problem, the worker will suggest at least two preventative measures to avoid the difficulty during installation.

Content

1. Illustrate and discuss causes of excessive bleeding. Point out remedies and steps to prevent the problem.
2. Illustrate and discuss causes of excessive curling. Point out remedies and steps to prevent the problem.
3. Illustrate and discuss causes of dusting. Point out remedies and steps to prevent the problem.
4. Illustrate and discuss causes of scaling. Point out remedies and steps to prevent the problem.
5. Illustrate and discuss causes of random cracking. Point out remedies and steps to prevent the problem.
6. Illustrate and discuss causes of map cracking. Point out remedies and steps to prevent the problem.
7. Illustrate and discuss causes of color differences. Point out remedies and steps to prevent the problem.
8. Illustrate, discuss, and demonstrate how to install reinforcement. Discuss actions, problems, and precautions.
9. Illustrate, discuss, and demonstrate how to install vapor barriers. Discuss actions, problems, and precautions.

Reference

Job Functions	**Sample Tasks and Activities**
Horizontal Placement	Monitor environmental conditions and adjust process
Vertical Placement	Install moisture barriers/vapor barriers
Mass Placement	Apply curing agents
	Apply admixtures of all types
	Maintain moisture and heat during curing

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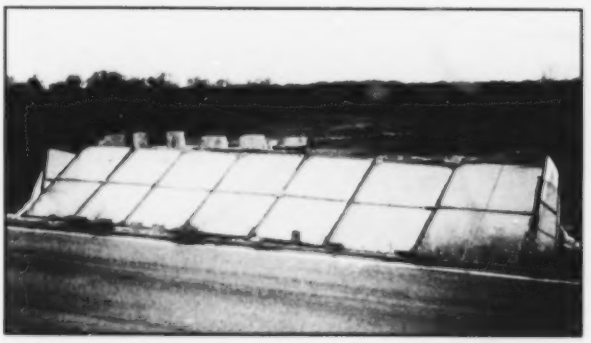
IDENTIFY AND KNOW PROCEDURES TO ADAPT/CONTROL FOR ENVIRONMENTAL PROBLEMS

Context

Moisture, temperature, and air movement all affect the chemical reaction of cement. Concrete workers routinely must adapt procedures to account for environmental conditions. Most often, compensation for environmental conditions will consist of using admixtures, temperature adjustment, moisture compensation, and curing protection. However, changes require adjusting other parts of the process to ensure proper strength gain and adequate surface finish.



Mastery Performance

1. Given an environmental condition, a worker will match the condition to the effect and the proper work adjustments they must make.
2. Given an adjustment, such as retardant or accelerator, a worker will describe at least three procedures to use when dealing with the application.
3. Given temperature requirements, worker will monitor and record temperature within 1 degree.

Content

1. Illustrate environmental conditions and their effects on concrete.
2. List and demonstrate techniques to deal with environmental conditions.
3. Develop a list of actions and illustrate the effects of techniques.
4. Demonstrate and practice handling differences for hot weather, cold weather, and admixtures such as super-plastizers, retardants, accelerators, and so forth.
5. Discuss how techniques affect other parts of the process such as curing and finishing.

Reference

Job Functions	**Sample Tasks and Activities**
Horizontal Placement	Read gauges to assess concrete before placement
Vertical Placement	Apply curing materials
Mass Placement	Adjust water in mix before placement
Mass Curing	Maintain moisture and heat during curing
Horizontal Curing	Attend to time constraints
Vertical Curing	Add/incorporate admixtures of all types at correct rates
	Read thermometers to follow temperature range

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